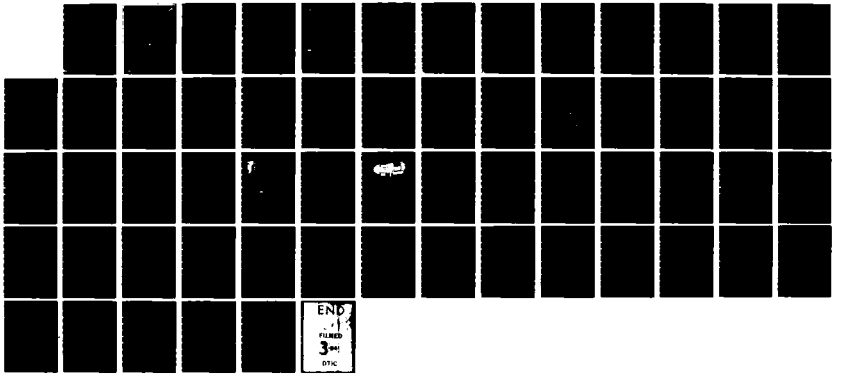
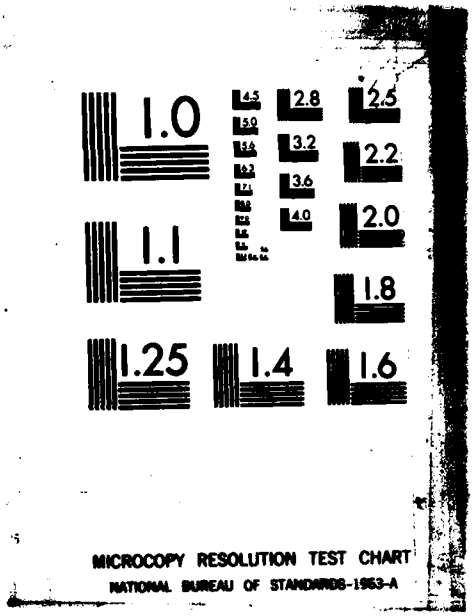
AD-A137 652 EUROPEAN SCIENTIFIC NOTES VOLUME 38 NUMBER 2(U) OFFICE OF NAVAL RESEARCH LONDON (ENGLAND) L E SHAFFER FEB 84 ESN-38-2 1/1

UNCLASSIFIED F/G 5/1 NL



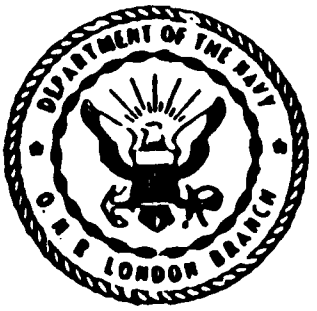

1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

OFFICE OF NAVAL RESEARCH
LONDON

EUROPEAN SCIENTIFIC NOTES

ESN 38-2

February 1984



Distributed by the
Office of Naval Research Branch Office,
London

This document is issued primarily for the information of U.S. Government scientific personnel and contractors. It is not considered part of the scientific literature and should not be cited as such.

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 38-2	2. GOVT ACCESSION NO. AD-A137652 / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EUROPEAN SCIENTIFIC NOTES	5. TYPE OF REPORT & PERIOD COVERED Monthly February
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Larry E. Shaffer, editor	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Office of Naval Research Branch Office London Box 39 FPO NY 09510	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE February 1984
	13. NUMBER OF PAGES 51
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

European Scientific Notes (ESN) is a monthly publication with brief articles on recent developments in European scientific research. The publication is not intended to be part of the scientific literature. The value of ESN articles to Americans is to call attention to current developments in European science and technology and to the institutions and people responsible for these efforts. ESN authors are primarily ONRL staff members. Occasionally articles are prepared by or in cooperation with staff members of the USAF

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

European Office of Aerospace Research and Development or the US Army Research and Standardization Group. Qualified US scientists travelling in Europe may also be invited to author an ESN article.

EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON

Edited by Larry E. Shaffer

February 1984
Vol 38, No. 2

BEHAVIORAL SCIENCES

New English and Dutch studies of problem solving have important implications for US research.

BIOLOGICAL SCIENCES

France is helping establish an International Biotechnology Training Network and is funding a new building for biotechnology at the Institut Pasteur in Paris.

Using genetic engineering, researchers at the London School of *Hygiene and Tropical Medicine* may have found a new, affordable way of producing vaccine against hepatitis B.

CHEMISTRY

The University of Hamburg is establishing an Institute for Technical and Macromolecular Chemistry.

COMPUTER SCIENCES

The primary goal of the European Strategic Planning of Research and Development in Information Technology (ESPRIT) program is to encourage the cooperation necessary to make Europe competitive in the world market in information technology.

Researchers are developing robots that can avoid obstacles, walk along walls, and escape from partial confinement.

EARTH SCIENCE

Over the past 13 years Oxford University has increased considerably its activities in geomorphology.

The UK has two centers for climate and weather forecasting with outstanding reputations: the European Center for Medium-Range Weather Forecasting and the Climate Research Unit.

ELECTRONICS

The conference focused on the quantum Hall effect and the anomalous quantum Hall effect, and presented other topics dealing with low-dimensional electronic properties in solid-state matter.

ENGINEERING

The underwater acoustics program at the University of Birmingham (UK) includes research projects on propagation, transducer development, and signal processing.

MATERIAL SCIENCES

Polycrystal strength properties, fracture mechanics testing, composite (wind turbine) materials, energy storage materials, battery-related research, and nondestructive testing are activities at Risø, which is continuing host for the annual international symposium on metallurgy and materials science.

The ICCS/2 meeting dealt with fiber reinforced plastics and covered acoustic emission, failure properties, structural design of components, and engineering structures ranging from automotive tires to naval gun turrets.

OCEAN SCIENCES

The environmental implications of wave-energy converters are discussed in a recent article in *Ocean Engineering*.

The Laboratoire de Telecommunications et d'Hyperfrequences at Université Catholique de Louvain has a remote sensing program sponsored by the European Space Agency. Recently, the program was favorably evaluated by an international panel of experts.

PHYSICS

Researchers in the Federal Republic of Germany have developed the gas-liner pinch to overcome limitations of gas-puff plasma radiation sources.

Recently there has been much interest in active noise control. Does this indicate that the approach is about to move beyond laboratory demonstrations and have an impact on operational noise control?

Although the focus of the 16th European Conference on Laser Interactions with Matter (ELCIM) was inertial confinement fusion, a number of presentations dealt with experiments and theory concerning soft x-ray lasers. Results in this area are presented.

SCIENCE POLICY

Recommendations from the Advisory Board for the Research Councils indicate that there are lean times ahead for some fields of science in the UK.

SPACE SCIENCE

The Max-Plank-Institute for Extraterrestrial Physics has initiated a study to do infrared astronomy with an airborne telescope.

STATISTICS

Research in mathematical statistics at small universities in the Federal Republic of Germany has had a long and distinguished history; high-quality research is being carried out in small institutes having one or two professors and a few assistants.

NEWS & NOTES

Space physics school, by R.L. Carovillano; sonar-transducer conference, by Chester McKinney; space-math course, by R.L. Carovillano.

European Scientific Notes is a Class I Periodical prepared and distributed by the Office of Naval Research, London, in accordance with NAVEXOS-P-35.

James W. Daniel
Scientific Director

M.A. Howard
Captain, USN
Commanding Officer

BEHAVIORAL SCIENCES

HUMAN AND ARTIFICIAL INTELLIGENCE: SOME ENGLISH-DUTCH CONTRASTS

by Richard E. Snow. Dr. Snow is the Liaison Scientist for Psychology in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1985 from Stanford University, where he is Professor of Education and Psychology.

Interest in the study of intelligence, both human and artificial, has expanded rapidly in several directions through recent years. In one part of this research spectrum, investigators are analyzing relatively fast information processing in relatively simple kinds of problem solving, such as that required in common laboratory tasks and in conventional mental tests. Reaction time and error measures presumed to reflect the action of constituent stages or component functions in problem processing provide the medium for theory in this work. Some investigators search for general mechanisms underlying human and machine intelligence; others focus on the vast individual differences typically observed in human performances.

In another part of the spectrum, the aim is to understand the relatively slower and more complex kinds of problem solving, where the use of organized prior knowledge seems to play a large role in performance. Problems in medical diagnosis, in physical and biological sciences generally, and in complex games such as chess are the focus here. The data medium is likely to be the verbal and behavioral "tracks" (e.g., protocols) left by the problem solver in action. Again, some researchers concentrate on general theory; others examine individual differences, such as those between expert and novice problem solvers, to test individual as well as general hypotheses.

Both kinds of work have come to rely on the computer program, either as realization of theory or as model for it. Indeed, the lines between research on human and artificial intelligence have now become fuzzy in some areas, and invisible in others.

The early roots of both these lines of work derive in significant part from contributions by English and Dutch investigators--notably, Galton and Donders' work in the last century on reaction time measures of cognitive functioning and the studies of Bartlett and De Groot in the middle decades of this century on complex learning and problem solving. Although other European and much US research has dominated these fields since 1960, new work in several English and Dutch camps has now revived old questions and posed new ones that challenge some of the premises that seem to have been taken for granted, especially by US investigators. The purpose of this article, the first in a series on intelligence research, is to introduce some of these questions. Later articles will attempt more detailed analyses of these and related questions arising from current European research on human and artificial intelligence.

An English challenge comes from H. J. Eysenck (Institute of Psychiatry, University of London) and his colleagues A.E. and D.E. Hendrikson in London, and C. Brand in Edinburgh. In brief, their argument is that Galton was right--or almost right--as far back as the 1860s, when he conceived of intelligence as a general mental ability reflecting physiological quickness, particularly in information intake, and measurable by reaction times in simple sensory-motor tasks. The modern work of Brand on "inspection" time and of Jensen in the US on choice reaction time seems to confirm earlier, and until now forgotten, reports: very simple reaction time measures in perceptual tasks yield very high correlations, in the -0.60 to -0.70 range (uncorrected), with intelligence as measured by standardized mental tasks such as the Stanford-Binet and Wechsler tests. According to Eysenck, these correlations can no longer be dismissed on methodological grounds or ignored simply because they do not fit the popular but more complex cognitive theories of intelligence.

Furthermore, old work suggesting correlation between tested intelligence and several features of EEG patterns has now been replicated and substantially extended by the Hendriksons. They report estimated correlations in the 0.70 to 0.80 range (uncorrected) for measures reflecting variation in average evoked potentials over standard durations and stimulus conditions. They go on to propose a theory wherein a common molecular mechanism in brain biochemistry underlies all recognition errors in neural pulse train transmission; these errors result in measured differences in the wave form of average evoked potentials that convert into differences in reaction time, and in turn account for all sorts of observed differences in learning, thinking, and problem solving. If such a theory proves tenable, it would appear to undercut the cognitive theories now prevalent in US research,

which assume a basic set of machine-like information processes that combine to account for the complex of intelligent behavior in human or machine. The main point is, then, that it may be the initial stages of information processing--problem *apprehension*, not problem *solving*--where the function of intelligence may be most clearly seen.

Certainly some bridges between the two kinds of theory can be imagined, and there are alternative physiological theories to that advanced by the Hendriksons. But in Eysenck's view the complex cognitive theories with their multiple processing mechanisms and combinatorial explanations of problem solving--Binet-type theories as opposed to Galton-type theories, he would call them--misdirect research away from rather than toward the true biological bases of intelligence, whatever these turn out to be. Artificial intelligence research, also, may be directed away from study of the initial heuristic search and comparison mechanisms earlier proposed as crucial to intellectual performance in English work by Furneaux and in Russian work by Sokolov.

Reports of some of the Eysenck, Hendrikson, and Brand work are available in Eysenck (1982) and *ESN* 35-8:31 (1981). Their work continues, and will be followed by this author. Also, independent re-analyses of some of their data are now in progress. Recently the four were principal speakers at a London symposium entitled "The Biology of Human Intelligence," sponsored by the Eugenics Society. The symposium proceedings will be published in 1984 (available from the General Secretary, Eugenics Society, 69 Eccleston Square, London SW1V 1PJ). The proceedings will also include contributions by M. Waterhouse on the evolution of intelligence, M. Shayer on gender differences in cognitive development, J. Hewitt and K. Last on recent data from twin studies of intelligence, J. Stevenson on the genetics of reading disability, N. Mascie-Taylor on biological and social correlates of IQ obtained in the National Child Development Study, R. Lynn on racial and ethnic differences in intelligence found in studies around the world, B. Stratford on the mentally handicapped, J. Freeman on gifted children, and M. Huntley on exceptional children in the family. Taken together, these papers provide a representative sample of that part of current British psychology that hypothesizes very strong biological determinants of human differences in intelligence.

Quite a different challenge comes from new Dutch research. Whereas the implication of the English work cited above is that US investigators assume too complicated an account of intelligence, some Dutch investigators argue that US views are too simple. They too, however, draw attention to the initial phases of problem solving as crucial.

One part of the challenge concerns how we should think about the initial pattern-recognition functions that set up a representation, or code, in the cognitive system that then can be worked upon. According to E. Leeuwenberg and H. Buffart (University of Nijmegen, The Netherlands) most modern theories of pattern recognition in humans and machines assume some kind of feature extraction process; features of the scene, event, text, or problem are identified as the basic units of the experienced patterns and are then used to classify the patterns for interpretation by applying a minimizing rule to handle irregularities. These features are assumed to be independent constituents of perception, though it has been shown that they cannot be. Theories based on such feature processing lead inevitably to the positing of many special-purpose perceptual machines because no general set of independent features can be constructed, and the minimizing rules used to classify percepts can trap the system in local nonoptimal *minima*. Such theories fail to explain various configurational or gestalt phenomena in human perception.

The Leeuwenberg-Buffart approach, called Structural Information Theory, concentrates instead on specifying the nature of the abstract code system that is the critical product of initial perceptual processing. The claim is that abstract interpretations, not representations of concrete experience, are processed. Just how initial perceptual processing takes place is not specified by the theory. Rather, it is supposed that several primitive codes (i.e., interpretations) of a stimulus situation are developed by the observer simultaneously, and a minimum end-code (i.e., the preferred interpretation) is sought by means of operations that reduce information load (i.e., the number of irregularities in a given code). Processing thus becomes more complex, in a sense, than in feature extraction theories, in order ultimately to be simpler.

In contrast to the English approach, the Dutch structural information theory is not concerned at all with reaction time or fine sensory discrimination; it fits more comfortably with the phenomenological tradition in European psychology. But the theory

accounts well for a variety of empirical results relating to both feature and configurational phenomena, and provides a coherent way to describe both detail and gestalt in perception, and both common and distinctive aspects of concepts. It may also thus provide a way to improve computer perception programs substantially over what is now possible with the US approach. The work is being extended to research on memory, and the computerization of the coding system. A discussion of the theory as a bridge between gestalt and information processing traditions is available from Restle (1982). A detailed exposition of the theory and further developments may be obtained from laboratory reports by Leeuwenberg and Buffart, Department of Psychology, University of Nijmegen.

Another Dutch research group--involving J.J. Elshout, B.J. Wielinga, and other colleagues at the Institute for Cognitive Studies, University of Amsterdam--has been studying problem solving in thermodynamics in a way that raises questions about expert versus novice comparisons in US research. Again the focus is on the early stages of problem processing. Data from students in the beginning and intermediate stages of learning physics suggest that a "basic mechanisms" approach that concentrates too much on problem solution, and too much on experts, misses the orientation phases of problem solving. Novices are not empty experts; rather they are beginners who operate on a knowledge base brought to the task from prior experience. This knowledge base is bookish and impressionistic rather than procedural, it is disorganized and incomplete, and it contains incorrect ideas. The task of learners in the orientation phase, therefore, is to create some order in this chaos--to discover their incorrect ideas, to avoid jumping too quickly to superficial solutions, to develop heuristic strategies for analyzing problems and planning solutions, to recognize different types of problems and, in general, to make well-ordered, soluble problems out of apparently disordered ones. A computer model must reflect this "higher-order" activity in the orientation phase and operate within it, if the model is to represent the psychology of problem solving adequately.

The Elshout group has now created such a computer model, called a protocol diagnostic program. Its ultimate aim is to explain all the learner's activities during problem solving, including those suggesting erratic or incorrect behavior, and to represent all the stages of skill acquisition from novice through expert. The practical goal is to fit the program to serve as an intelligen coach for use in instruction. In its present form, it consists of three components and a knowledge-representation system that is flexible. The PERFORM component includes the hierarchical network of procedural and declarative knowledge about physics that is needed to solve problems in a way that models the human subject. The ANALYZE component is a system of production rules that produces a "think aloud" protocol representing the events generated by PERFORM. When this protocol does not agree with the protocol generated by the human subject, the DIAGNOSE component is called. It is equipped with rules about deviations from the normal line of behavior of the model, and can identify difficulties and redirect the model performance. So far, the program simulates the behavior of intermediate students (those with 1 year of physics instruction), though it does not yet handle adequately the more erratic aspects of novice behavior. A revised version of the program is being developed, and new experiments are planned to extend the model to cover more fully both novices and experts. A brief English-language report on part of this work is available from Jansweijer, Konst, Elshout, and Wielinga (1982).

Still another challenge comes from L. DeLeeuw and his research at the Free University of Amsterdam psychology department. In this work, computerized instructional programs that attempt to improve the problem-solving abilities of public school students have been evaluated; measures of ability and personality characteristics of the students have been used as moderator aptitude variables. One instructional program uses a highly structured algorithmic approach, in which the necessary operations and their sequencing in problem solving are exhaustively prescribed for the student and practiced. The comparison program uses a less structured heuristic approach, in which students are guided toward discovery of the necessary operations and sequencing for themselves, with well-placed helps available in the course of instruction. The programs have been tried out on both inductive and deductive reasoning problems (number series extrapolations and syllogisms) representing two levels of complexity or difficulty.

Results suggest that student aptitudes interact with the instructional treatment contrast, particularly on more complex problems. Students characterized as low in negative fear of failure (i.e., debilitating anxiety), or

high in critical thinking and related intellectual abilities, or both, performed better with heuristic instruction than with algorithmic instruction. The students high in debilitating anxiety, or low in relevant abilities, or both, did better with algorithmic instruction. Within the heuristic program, the anxious students asked for help more than others and benefited from it less, particularly on the complex problems.

Such results correspond to findings from instructional studies in a variety of subject-matter areas. But the Dutch work goes further to indicate that the same patterns of interaction between student aptitudes and instructional methods occur when the aim of instruction is to develop problem-solving abilities directly. The implication is that problem-solving abilities may not be developed in the same way in all persons; in particular, precise teaching of algorithmic problem-solving procedures is good for anxious, less able beginners but bad for the more able and less anxious beginners, whose learning may be more heuristic and idiosyncratic. A brief report in English of part of this work is available from De Leeuw (1983).

In summary, there appear to be at least four related and important issues to examine in the search for improved theories of intelligence:

1. Fast processing of relatively simple problems and slow processing of relatively complex problems may exist on a continuum. Qualitative changes may or may not be needed in the cognitive models that describe performance along this continuum, but research on this question will need to identify and address at least the major regions in between.

2. In particular, alternative models of the initial stages of problem processing have been ignored in favor of work on the later stages of problem processing. The models adopted to account for the initial stages have different implications and different strengths in relation to models of later stages of processing.

3. The acquisition of problem-solving abilities also needs to be studied in more detail, especially at novice and intermediate levels in relation to expert performance. This research should be sensitive to qualitative differences in higher-order strategic and planning processes as well as to assumed elementary information processes.

4. The underlying sources of individual differences in performance may or may not be the same in different regions of complexity, stages of processing, and levels of acquisition. Ongoing research will need to account for the apparent commonality of individual differences in simple error and reaction time performance and in complex problem-solving performance, as well as for the distinctive correlations of certain ability and personality characteristics obtained as problems and instructional contexts for problem solving change.

References

De Leeuw, L., "Teaching Problem Solving: An ATI Study of the Effects of Teaching Algorithmic and Heuristic Solution Methods," *Instructional Science*, 12 (1983), 1-48.

Eysenck, H.J., ed., *A Model For Intelligence* (Berlin: Springer-Verlag, 1982).

Jansweijer, W.N.H., L. Konst, J.J. Elshout, and B.J. Wielinga, "PDP: A Protocol Diagnostic Program for Problem Solving in Physics," *Proceedings of the European Conference on Artificial Intelligence* (Paris, 1982).

Restle, F., "Coding Theory as an Integration of Gestalt Psychology and Information Processing Theory, in *Organization and Representation in Perception*, ed., J. Beck (Hillsdale, NJ: Erlbaum, 1982).

11/7/83

BIOLOGICAL SCIENCES

FRANCE BACKS BIOTECHNOLOGY RESEARCH

by Thomas C. Rozzell. Dr. Rozzell is the Liaison Scientist for Biological Sciences in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until August 1985 from the Office of Naval Research, Arlington, VA, where he is Group Leader for Cellular Biosystems.

During the past summer, the governments of France and the UK agreed to take the lead in establishing an International Biotechnology Training Network (IBTN). The work is being done in conjunction with the governments of other European countries, Japan, and Canada, and with agencies such as the United

Nations Educational, Scientific, and Cultural Organization (UNESCO), and the World Health Organization (WHO).

The program appears to have two major objectives: (1) to obtain the essential information in the emerging technologies at a lower cost than would be possible through purely national programs, and (2) to increase the pool of trained biotechnologists required to meet the needs of the developed and developing countries.

Under the plans laid out by the participating governments, these objectives will be met by first establishing a network of new and existing training centers that will cover the broad range of disciplines of biotechnology, and then encouraging cooperation between nations in research and development in specific project areas. An International Committee, supported by an executive secretariat, is to coordinate, develop, and monitor programs in areas proposed by the national and international representatives on the committee.

The Executive Secretariat of the IBTN is responsible for coordinating and conducting the operations of the Network. The Secretariat prepares the International Committee meetings, circulates information concerning training and research programs of the participating countries, and helps organize consultations between the countries. The Secretariat is being hosted by France for the first 3 years and is currently located at the Centre d'Etudes des Systemes et des Technologies Avancees, 5, rue Descartes, Paris.

The International Committee, composed of experts from among interested industrialized nations and the European Commission, will advise the Network. The committee will be asked to designate a representative for each of the countries participating in the Network; the representative is to be assisted by an adviser. Representatives from UNESCO, the Food and Agricultural Organization (United Nations), WHO, the United Nations Industrial Development Organization (UNIDO), and the US will be allowed to send observers to the meetings of the International Committee.

That the French government is making a substantial investment in research in general and biotechnology in particular is borne out by the fact that a law was passed recently to ensure that its research budget must rise to 2.5 percent of the gross national product. Biotechnology research enjoys a high level of priority under this new policy. Further evidence of the government's commitment is seen in the expansion of the Institut Pasteur in Paris where a new building is now under construction. The new six-floor facility which will be devoted entirely to biotechnology, will cost the government about $7.75 million. The Institut Pasteur--which is private, but about 50 percent state-supported--will spend an additional $3 million to purchase equipment. The building will have approximately 3000 m² of laboratory space. Construction is slated for completion in 1986. The new building will be operated by the Institut Pasteur, which has pledged to coordinate its research policies with the Centre National de la Recherche Scientific, Institut Nationale de la Santé et de la Recherche Medicale (the medical research council), and Institut National de la Recherche Agronomique (the agriculture research institute). A number of users will share the laboratory; the research will be both fundamental and applied, and oriented to health and to industry. When completed, this new addition to the Institut Pasteur, the new attitude of the state, and the IBTN involvement should put France in a position to compete as a world leader in biotechnology, as it has done in a number of other areas of biological research.

11/18/83

NEW HEPATITIS VACCINE

by Thomas C. Rozzell.

Dr. Arie Zuckerman and coworkers at the London School of Hygiene and Tropical Medicine may be on the road to a new and better approach to a much-needed vaccine against hepatitis B--a disease that affects millions, especially in Third World countries. Patients in hospitals and other closed treatment facilities where transfusions and skin punctures are frequent are particularly at risk--and battlefield medical units are good targets for hepatitis B.

The hepatitis B virus cannot be grown in tissue culture, and this has prevented the development of vaccines by conventional methods. Therefore, research has focused on the use of other preparations to achieve active immunizations. The primary approach for the hepatitis B vaccines has, until now, been determined by the demonstration of the relative efficacy of diluted serum in preventing or modifying the infection in exposed individuals. (The diluted serum contains hepatitis B virus and its

antigens heated to 98°C for 1 minute.) The hepatitis B surface antigen, which leads to the production of protective antibodies, can be prepared as 22-nm spherical particles, and these have been used as vaccines.

To prepare such a vaccine, however, one must obtain plasma from human carriers of the disease. Although it is generally accepted that purified preparations of the 22-nm surface antigen particles are free of nucleic acid and therefore noninfectious, the fact that the starting material is human plasma obtained from persons infected with hepatitis B means that special care must be exercised to ensure that the preparation is free of all possible contaminating material.

Merck, Sharp and Dohme already has a fairly effective vaccine prepared from the infected blood of American donors. This vaccine consists of part of the virus coat carrying the hepatitis B surface antigen that stimulates the production of antibodies against the virus. The disease is not transmitted by this antigen but by the DNA in the core of the virus. Although Merck's vaccine is very pure and has been approved by the World Health Organization, there are fears that the donated blood could pass on other viruses and may cause diseases such as acquired immune deficiency syndrome (AIDS). Supplies of the human blood are limited, and each batch must undergo extensive testing in chimpanzees over a period of several months. This procedure makes the Merck vaccine very expensive--around $100 per dose--putting it effectively out of reach of many of the people who need it most.

Biochemical analyses have shown that the 22-nm particle is a complex structure consisting of lipid and several proteins of either host or viral origin /1/. A close association has actually been established between human serum albumin and the 22-nm particle /2/. Hepatitis B-specific antigenic determinants are associated with a nonglycosylated polypeptide with a molecular weight in the range of 22,000 to 24,000 and a glycoslyated polypeptide with a molecular weight in the range of 26,000 to 29,000. Both polypeptides have identical amino acid sequences at amino and carboxyl terminals, indicating that the larger one represents a glycosylated form of the smaller nonglycosylated polypeptide.

Nucleotide sequence analysis of the hepatitis B genome has shown that the surface-antigen gene product contains an internal sequence of 19 hydrophobic amino acids /3/, representing the site of polypeptide insertion into the lipid bilayer of the 22-nm particles. The hepatitis B-specific 28,000 and 23,000 molecular weight components may, therefore, be considered as integral membrane proteins, being partially hydrophobic and insoluble in aqueous media in the absence of detergents. The solubilization of the integral protein of hepatitis B surface antigen particles can be readily achieved by disrupting the lipid bilayer with nonionic detergents /2/. Generally, the biological and antigenic properties of viral proteins are preserved by this method. Such is not the case when strongly ionic detergents are used.

Monomeric solutions of polypeptides in detergents are poor immunogens and are therefore generally unsuitable as vaccines. The approach used by the London group involves a method of removing the detergent by sedimentation of the viral peptides into a detergent-free sucrose gradient under defined conditions. The membrane polypeptides then reassociate into water-soluble protein micelles /4,5/.

Protein micelles are aggregates of polypeptides arranged, in this case, such that the hydrophobic regions are sequestered in the interior of the particles with the hydrophilic residues on the surface, thus rendering the micelles water-soluble. The solubilized surface antigen polypeptides treated by this procedure consistently form 120-nm-diameter micelle structures. The buoyant density of the micelles was found to be 1.25 g/ml, compared with 1.19 g/ml for the original intact particles, an increase that is consistent with the removal of most of the lipid by the solubilization process. The final yield of the two polypeptides in micelle form was estimated to be 60 to 70 percent of the amount originally present in the 22-nm particles. This level of recovery of total protein confirms the suitability of the method for large-scale production of a hepatitis polypeptide vaccine.

Recently, Dr. Huub Schellekens at The Netherlands Organization for Applied Scientific Research (TNO) Primate Center (Rijswick, The Netherlands) tested a new recombinant DNA vaccine developed by Prof. Kenneth Murray of the University of Edinburgh. This vaccine was developed and tested in chimpanzees. The disease is similar in chimps and humans, giving additional hope that an effective human vaccine may not be far off.

The strategy used by Murray and his coworkers was to genetically engineer the production of the surface antigen protein by inserting the gene that codes

for it into the genetic material of yeast cells. The cells then make the viral protein along with their own. This in itself was not a new feat. However, when Schellekens at TNO tested this preparation in four chimps, he found that two of the animals remained perfectly healthy after being challenged with hepatitis B virus. This was the first time that anyone had reported a successful test with the genetically engineered product in higher primates.

However, even this vaccine may be too expensive for many Third World countries. It is projected to cost $10 to $20 per dose--with two to three shots, spaced months apart, usually being needed for protection that will last only about 5 years.

The vaccine developed by the London group is advantageous because it protected the chimps that were challenged with the virus, and much less vaccine was required. Comparison of the immunogenicity of the micelles with the 22-nm-particle vaccine in mice showed that at all levels tested the micelles elicited a more vigorous response from protective surface antibodies than did the intact particles. Safety and protective efficacy studies have been completed in susceptible apes in both London and the US. Clinical trials of the micelle vaccine are just under way.

Zuckerman and his coworkers estimate that with their vaccine the dose can be reduced to a single injection and one booster at a later time. They estimate that the cost of immunizing an individual will be significantly less than at present.

The critical issues now are whether antibodies induced by vaccines produced by genetic manipulation or by chemical synthesis will be protective, and whether such immunity will persist in the individual.

References

Howard, C.R., and C.J. Burrell, *Progress in Medical Virology*, 22 (1976), 36.

Skelly, J., C.R. Howard, and A.J. Zuckerman, *Journal of General Virology*, 44 (1979), 679.

Skelly, J., C.R. Howard, and A.J. Zuckerman, *Nature*, 290 (1981), 51.

Valenzuela, P., et al., in *Animal Virus Genetics*, ed. B.N. Fields, R. Jaenisch, and C.F. Fox (New York: Academic Press, 1980), 57-70.

Young, P., M. Vaudin, J. Dixon, and A. J. Zuckerman, *Journal of Virological Methods*, 4 (1982), 177.

11/28/83

CHEMISTRY

EXPANSION OF POLYMER RESEARCH AT THE UNIVERSITY OF HAMBURG

by Vivian T. Stannett. Dr. Stannett, formerly at ONR, London, is Camille Dreyfus Professor in the Chemical Engineering Department at North Carolina State University, Raleigh.

Dr. P. Fischer-Appelt, President of the University of Hamburg (Federal Republic of Germany) has announced major changes in the university's posture on polymers. During his opening of the 15th Europhysics Conference on Macromolecular Physics and the 1983 Hamburg Macromolecular Symposium, he said that a new Institute for Technical and Macromolecular Chemistry will be formed. It will incorporate the present polymer activities of the Department of Applied Chemistry, headed by Prof. H.G. Zachman, a specialist in polymer physics. There are three other professors in the department: H.R. Kricheldorf specializes in polymer synthesis and biopolymers, W. Kaminsky in polymerization and the useful pyrolysis of tires and biomass, and H.C. Broecker in nuclear magnetic resonance.

Prof. H. Sinn, who once headed the department, has been on leave since 1979 to serve as the Minister of Science and Research in the Hamburg state government. He has been very active in initiating and promoting the new institute and will return shortly to active research. Three new professorships will be created: one in fiber science, one in technical chemistry, and one in a field which still has to be defined. In addition, the institute will work closely with polymer scientists at the new Technical University created in 1981 at Hamburg-Harburg. Initial funding for the new institute will be DM 5 million, in addition to DM 35 million for a new building scheduled for completion in 1985.

10/5/83

COMPUTER SCIENCES

EUROPEAN FIFTH GENERATION COOPERATION AND ESPRIT

by J.F. Blackburn. Dr. Blackburn is the Liaison Scientist for Computer Science

in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the National Academy of Sciences, where he is Executive Director, Computer Sciences Board.

The European Economic Commission (EEC) has set up a new R&D program in information technology. The primary goal of the program, called European Strategic Planning of Research and Development in Information Technology (ESPRIT), is to encourage the cooperation necessary to make Europe competitive in the world market in information technology (see *ESN* 37-12:447-450 [1983]). ESPRIT was described by Horst Huenke (European Commission, Belgium) at the Fifth Generation World Conference held in London from 27 through 29 September 1983.

Technical panels met in June and July 1982 to determine what should be the technical objectives in information technology for the next 10 years and to plan a long-term program. Much attention was given to the subjects of office automation and integrated manufacturing. It was concluded that the EEC has a right and a duty to take the initiative in this field. The first 5 years of a 10-year program have been proposed. A pilot phase of the program began in 1983 with contracts let in January and July; the research and development work will be concentrated in the areas listed in Table 1.

Cooperative projects in precompetitive research and development will be important. Participants will systematically consult during the research and development process. There are open calls for proposals from industry and universities, and there will be regular consultation with industry and academia throughout the development process. The complete dissemination of information will be a standard objective. About 750 new projects are expected to start from 1984 through 1988. Thirty-eight pilot projects had been started by September 1983.

An EEC meeting was held in October 1983 to review the work already done on ESPRIT, to plan for the major program that will start beginning in 1984, and to plan a more comprehensive long-term information technology strategy.

According to Huenke, ESPRIT is needed because of several characteristics of the information technology industry in Europe:

- The market is somewhat fragmented.
- There are national champions for their products.
- Foreign-controlled companies are very important in the market.
- The center of innovation in information technology has migrated from Europe.
- There is a shortage of skilled manpower.
- There are substantial lags in getting new products to the market.
- In many cases the profitability is low.

Information technology has an important economic and employment impact

Table 1

Areas for R&D

1. Microelectronics
   a. Very large scale integration
   b. Integrated sensors
   c. Opto-electronics
   d. Flat panel displays
   e. Compound semiconductors
   f. Novel organic and inorganic materials
2. Software technology
   a. Theories and methods of software development
   b. System construction and development
   c. Methods and tools in software engineering
3. Advanced information processes
   a. Information and knowledge engineering
   b. Signal processing
   c. Advanced interfaces
   d. Information and knowledge storage
   e. Computer architecture
4. Office automation
   a. Systems sciences
   b. Work stations
5. Computer integrated manufacturing
   a. Integrated systems architecture
   b. Systems and general software

and will play a significant role in the balance of trade between the EEC countries, the US, and Japan. In recent years the EEC has had a positive balance of trade with the US, but a negative balance with Japan. It is hoped that ESPRIT will improve the EEC's position.

11/3/83

RESEARCH ON WALKING ROBOTS AT THE UNIVERSITY OF PARIS VI

by J.F. Blackburn.

France is one of the few countries experimenting with walking robots. The work is being done at the University of Paris VI under the direction of Prof. J.J. Kessis.

Stationary manipulator robots are widely used today in production tasks in factories, especially in the automotive industry (*ESN* 37-6:205-208 [1983]). However, there are potentially many more tasks that could be performed by mobile robots. For example, there are possible applications in terrestrial, ocean bottom, and space exploration; mineral prospecting; and maintenance or repair in difficult environments, such as in nuclear plants. In order to realize these possibilities, research on mobile robots is under way in the areas of microcomputer control, sensors of various kinds, perception, environment modeling, and decision making.

The University of Paris VI is concentrating its research on walking robots because they have advantages over wheeled robots in some situations. The researchers believe legged locomotion is the best way to traverse virtually any terrain because it causes the least ecological damage and because their robots have good body stability. To be successful, walking robots need to be designed with high levels of artificial intelligence software.

The Place of Walking Robots in Robotic Research

Walking robots, like other mobile robots, must sense the environment to carry out their mission. Also, the flexible anatomy of a walking robot is similar to that of industrial robots; given a locomotion task in task coordinates, it must find a corresponding set of articular coordinates. Robots and manipulators also need high-level computer languages that specify tasks.

However, some features, concepts, and problems are specific to walking robots. Terrain adaptability is one problem. It is necessary to model the terrain, as well as other environmental features, and generate decisions based on these features.

The university staff has designed and built two six-legged robots, which share the same general logic and control architecture. A small one, H1, is operating, and the larger H2, designed for a 40-kg payload, is being finished now. It will allow use of various sensor equipment and possible battery operation for increased autonomy.

Both robots have a rotating ultrasonic range finder operating under the control of the plan language, and an equilibrium sensor. A joy stick will allow the larger robot to be hand-driven; this could be useful for maintenance tasks.

The Physical Control Levels

The leg level is a mechanical and servo level (a control stage) designed to simplify control; Kessis calls this level 1. Two servo motors are used to control each leg in Cartesian x and y coordinates. On H1, the leg mechanism is a triangle and pantograph system, while H2 has a direct Cartesian mechanism.

A level of control called the tonus level was added for tonicity--i.e., to improve systemic control of all functions of the system. A separate microprocessor was found to be necessary for continuously sending orders to the servo motors simultaneously with gait calculation. This is not required for the H2 motors but is conceptually useful for implementing "reflex" adaptability.

The Gait Concept

The researchers introduced a gait concept (level 2) based on the movement of animals and insects. The problem was to design a gait generator that gives a continuous control pattern for all degrees of freedom (DOF) of the robot. The following approach is used.

Let n be the number of legs, each with p DOF. Then the total number of DOF is np. The unit of elementary time (e.t.) is arbitrarily chosen to be long enough for execution of any elementary command. In the model all legs have the same cycle (regular gaits). A gait is then a vector of phase shifts ϕ_i between legs.

Let T be the duration of a leg cycle in units of e.t., a multiple of the number of independent legs. In a hexapod "tripled" gait there are only two independent legs; T may be as short as four, because two e.t.'s are required

for the return stroke, and two more for the power stroke.

Since gait is cyclic, it is useful to consider a cyclical time: $T = t \pmod T$. And the control sequence of the reference leg (leg 1) is a vector function of cyclical time:

$$L_k(T) \quad (k = 1. \ . \ . \ p).$$

Then T different L_k form a p×T matrix, which describes the leg cycle.

Given the $L_k(T)$ and the ϕ_i, the whole control sequence may be generated. For convenience, introduce a leg cyclical time, θ_i: $\theta_i = (T + \phi_i) \pmod T$, with $\theta_i = T$ for reference leg 1.

The control sequence for leg i is expressed as a function of its own cyclical time:

$$C_{ik} = S_{ik} A_{ik} L_{ik}(\theta_i) \quad (k = 1, \ . \ . \ ., p).$$

The robot's control pattern (elementary command) at time t is the p×n matrix C_{ik}. The A_{ik} and S_{ik} parameters modulate every DOF amplitude and sign, respectively, in order to solve turn problems, for instance. Centering parameters are introduced for terrain adjusting.

The gait generation problem is now reduced to finding an algorithm which gives the ϕ_i. For example, a gait is symmetrical when

$$\phi_{n-i+1} = (\phi_i + T/2) \pmod T \quad (i = 1, n/2).$$

It is wavy with a propagation time w when

$$\phi_i = (\phi_{i-1} - W) \pmod T \quad (i = 1, \ldots, n/2).$$

Thus a wavy symmetrical gait depends only on parameter w, which may vary between 1 and T-1. For the hexapod, T = 12 and W = 8 gives the maximal stability 142635 gait, while T = 12 and W = 6 produce the "tripled" gait (or, according to the above discussion, T = 4 and W = 2).

The system generates gaits as a function of the duration of a leg cycle T, the control sequence of reference leg $L_k(T)$, the amplitudes A_{ik}, the signs S_{ik}, and a phase-shift rule giving the θ_i. The function may be arbitrary (n-1 parameters) or structured according to classical descriptions (e.g., wavy). Every gait is referenced in the system by a gait number which is mapped to a gait table. The gait table includes all the gait parameters described above. The gait generator uses the gait table to produce the robot's control pattern.

The Plan Level and LP 4.5 Language

The aim is to obtain autonomous behavior by generating plans according to goals, environmental models, and terrain. Level 3 is a plan interpreter of a plan language, called LP 4.5, which has as its fundamental statement a pair (gait and duration). Gaits, as defined by level 2, are among the primitives of level 3. The plan language also includes condition also, sensor tests, and linkage to special-purpose machine language calls.

LP 4.5 is a language of a high enough level to relieve the programmer of the task of taking care of "effector": leg control. This characterizes LP 4.5 as an object-type language for manipulators. From the point of view of a computer scientist, LP 4.5 is similar internally to an assembly language including conditionals. The source code is assembled to generate evolutive plans which are interpreted to control the robot. Table 1 shows the instruction set of LP 4.5.

Although LP 4.5 is designed for generation by level 4, handwritten LP 4.5 plans allow such autonomous behaviors as edge following, escaping, and avoiding obstacles. LP 4.5 is also useful for testing a capability such as equilibrium recovery before its implemention at a lower level.

The Intelligence Level

The intelligence level (level 4) controls the overall behavior of the robot by generating LP 4.5 programs for the plan level for execution. The intelligence level constructs the programs by selecting a strategy for the robot to follow to achieve a goal--for example, moving a robot from room to room. Goals may be externally specified by a user, or they may be generated by the system as sub-goals during the achieving of another goal. Each strategy contains a prototype LP 4.5 program segment which is given data corresponding to the robot's current environment. In this way, general plans for traversing rooms or following passages that are encoded as plan segments can be adapted to specific situations. Several plan segments can be joined together to achieve more complicated goals for which a single strategy is not sufficient.

The robot internally represents its environment in a "world map." This map is a hierarchical symbolic description of spaces, objects and their connectors. The map is incrementally constructed as the robot explores and encounters new situations. With a complete and current world map, the robot can discriminate among competing strategies.

Table 1

Instruction Set for LP 4.5

Instruction	Description
ALLU n,t	Select gait n and execute that gait for t e.t.'s
ALLC t	Execute the current gain for t e.t.'s
CHBA a	Switch to the a-th gait bank
REPO t,n	Initialization command. The robot retracts its legs (the robot rests on a pedestal), resets the gait cycle counter, and initializes for gain n, and wait t e.t.'s
DEBT	Stand up command (executed after a REPO)
TMPO n	Sets the value of e.t. to n
CNTR p,v	Equilibrium adjustment. Sets let p's vertical centering to v
BRAN l	Unconditional branch to label l
BEVE c, l	Branch on condition code c to label l
BARI p, l1, l2, l3	Arithmetic branch on contents of register p
CONS v1, vd	Set sensor register to range v1+/-vd
RADF p	Set telemeter to angular position p
RADM p	Set telemeter to p and rotate 360 degrees
EXAM p,n	Call routine p, passing it argument n
MONI n	Branch to monitor entry point n
EXIT	Return

Conclusions

When properly equipped with plans that are controlled by the intelligence level, the robot can avoid obstacles, walk along walls, and escape from partial confinement. Future work is planned for further development of the walking robot language, automatic generation of such a language using artificial intelligence techniques, and testing prototype robots.

Currently, the intelligence level is interfaced with a simulation of the actual robot. Actions performed by the robot are reflected in an independent model of the environment. Sensory information is entered as a symbolic description directly into the data base. This prototype will allow better measurement of robot performance when the difficulties of noisy data and imprecise execution of actions are introduced.

References

Beni, Ricardo, and Susan Hackwood, eds., *Recent Developments in Robotics* (New York: John Wiley Publishing, forthcoming).

Kessis, J.J., J.P. Rambaut, and J. Penne, "Un Robot Mobile Hexapode--Architecture et Language de Plans," *Etat de la Robotique en France*, Tome 1: Recherche, Hermès (Paris, 1982), 3.

11/3/83

EARTH SCIENCE

GEOMORPHOLOGY PROGRAM DEVELOPING AT OXFORD

by Robert Dolan. Dr. Dolan is the Liaison Scientist for Geology and Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the University of Virginia, where he is Professor of Environmental Sciences.

It is my impression that geomorphology (the study of landform evolution) in the UK has been a stable academic field over the past decade. Most universities have had two or three faculty members and perhaps a few graduate students in this area of specialization. There are no large centers of geomorphological research in the UK similar to the dozen or more places in the US. However, recent developments at Oxford University suggest that there may be an outstanding program developing there. In fact, Oxford now claims to have the largest and most productive research school in geomorphology in Britain.

In 1970 there were only two faculty members with research interest in geomorphology working in the School of Geography at Oxford. By October 1983, the number had increased to more than five-fold. The researchers and their specialties are listed below.

Dr. M.M. Sweeting: processes in tropical karst, limestone crusts and diagenesis in relation to karst landforms, paleokarst, isotope studies of limestone wafers and deposits, karst in China.

Dr. A.S. Goudie: desert geomorphology with particular emphasis on rock weathering, duricrusts, and sand dunes; loess formation in the USSR; Pleistocene environmental change in the tropics and subtropics, with particular reference to Swaziland and South Asia; Pleistocene of the Oxford region.

Dr. B.A. Kennedy: morphology of small drainage basins, principally on sedimentary rocks, with particular reference to eastern France; the history of fluvial geomorphology.

Dr. F.A. Perrott: quaternary stratigraphy and sedimentology; climatic change; lake sediments and shorelines, with particular reference to Africa (especially Ethiopia), the southwest US, and Mexico; glacial chronology (Colorado Rockies, East Greenland, Karakoram).

Dr. P.A. Bull: cave sediments, with particular emphasis on structures and micromorphology; electron microscopy of sands and silts (quartz, feldspar, garnet, and clay minerals); fluvial sedimentology; loess; varves; tillites.

Dr. M.A. Summerfield: surface and near-surface silica diagenesis, with particular reference to silcretes and allied deposits in the Cenozoic of southern Africa, Britain, and France; weathering processes and products in humid tropical environments; large-scale landform development.

Mr. N. Gardner: hillslope geomorphology, terrain evaluation, and applied soil studies. Current research interests in soil-slope relationships; soil degradation assessment; rill and gully initiation and development in semi-arid environments; use of remotely sensed data in studies of soil erosion and soil variability; inherent limitation of geomorphic and soil-survey data in statistical analyses.

Miss S. Harrison: quaternary stratigraphy and sedimentology; quaternary geomorphic and environmental reconstruction from lake sediments and shorelines, with particular reference to New South Wales; lunettes formation and environmental significance; soils, with particular reference to the development of mobile topsoils and texture contrast, solid micromorphology, and micro-fabric development.

Dr. B. Gomez: sediment transport in gravel-bed channels, with particular reference to the bedload transport process; sediment transport processes in temperate valley glaciers, with particular reference to the transport of glacial debris; evolution of coarse-grained fluvial environments, with particular reference to Dartmoor and Southern Cyprus.

Dr. S.J. Gale: hydraulics of conduit flow in aquifers, secular variations in geomagnetism during the Quaternary in the southeast Asian non-dipole field, Paleokarst in the Morecombe Bay area.

From 1970 to 1983 the number of research students in the program also has increased; at present there are over 20 working on their PhDs. Most of the students from the UK are funded by the Natural Environment Research Council, but the program has attracted several graduate students from overseas.

The geomorphologists at Oxford have greatly increased their laboratory investigations in recent years. For example, Sweeting has been closely involved with the Atomic Energy Research Establishment (AERE, Harwell) in connection

with radiometric dating techniques, especially ^{14}C tritium and uranium series methods. A number of research assistantships have been held by Sweeting's postgraduates in association with AERE. Sweeting is also involved in cooperative studies with researchers in the People's Republic of China, as well as with European laboratories involved in limestone studies. Goudie is National Correspondent on Program 184 of the International Geological Correlation Program (Palaeohydrology of Low-latitude Deserts). He and his graduate students are also involved in experimental and field studies of sand movement. Kennedy is developing laboratory studies of stream channel confluences in association with colleagues at Colorado State University. Perrott has established the tropical paleoenvironments research group in association with members of the Radiocarbon Accelerator Unit in Oxford and is carrying out detailed sedimentological and chemical analyses of lake cores from several parts of the world.

The group at Oxford is building a well-equipped research laboratory for sedimentological and chemical analyses. A recently added Computer Interfaced Liquid Sediment Analyzer (CILAS) Particle Size Analyzer (715 Granulometer) will greatly improve their research of lake cores and soils, reducing the laboratory time for fine-fraction sizing from days to minutes. Their geochemistry laboratory is used for analyzing lake and river waters, groundwater, lake sediments, and soil and rock samples. Atomic absorption spectroscopy forms a central part of several research projects. Current field research is under way in areas such as Africa, China, Malaysia, New Zealand, Latin America, and North America.

The following references are representative of a 1978-1982 listing of 145 publications for the gemomorphologists at Oxford.

Bull, P.A., "Environmental Reconstruction by Electron Microscopy," *Progress in Physical Geography*, Vol 15, No. 3 (1981), 368-397.

Bull, P.A., et al., "Operator Variance in Quartz Grain Surface Studies," *Sedimentology*, in press.

Gardner, N., and A. Harrison, "Political Perspectives on Remote Sensing," *Proceedings of the International Conference on Matching Remote Sensing Technologies and Their Applications* (Reading, UK: Remote Sensing Society, 1981).

Gomez, B., "Representative Sampling of Sandy Fluvial Gravels," *Sedimentary Geology*, in press.

_____, "Temporal Variations in Bedload Transport Rates; the Effect of Progressive Bed Armouring," *Earth Surface Processes and Landforms*, in press.

Goudie, A.S., "Arid Geomorphology," *Progress in Physical Geography*, Vol 5, No. 3 (1981), 420-428.

Goudie, A.S., and K. Pye, eds., *Chemical Sediments and Geomorphology*, (Academic Press, forthcoming).

Harrison, S.P., and F.A. Street-Perrott, "Lake-Level Fluctuations," *in Quantiative Paleoclimate Analysis and Modeling*, ed. A. Hecht (New York: John Wiley, forthcoming).

Perrott, F.A., and S.P. Harrison, "Low Latitude Lake-Level Fluctuations," *Proceedings of the 4th Ewing Symposium on Climate Processes: Sensitivity to Solar Irradiance and CO_2*, Maurice Ewing-Series, American Geophysical Union, 4 (New York: Lamont-Doherty Geological Observatory, forthcoming).

Summerfield, M.A., "Distribution, Nature and Genesis of Silcrete in Arid and Semi-arid Southern Africa," *Catena*, in press.

_____, "Origin and Palaeoenvironmental Interpretation of Sarsens," *Nature*, 281 (1979), 137-9

Sweeting, M.M., and N. Lancaster, "Weathering and Solution of Limestones in Namibia," *Zeitschrift für Geomporphologie*, in press.

Sweeting, M.M., P. Thorpe, and R.L. Otlet, "Hydrological Implications from C14 Profiling of UK Tufa," *Radiocarbon*, Vol 22, No. 3 (1980), 897-908.

11/29/83

NORTH SEA CLIMATE AND NORTH SEA STORMS

by Robert Dolan.

The UK has two centers for climate and weather forecasting with outstanding reputations: the European Center for Medium-Range Weather Forecasting at Reading and the Climatic Research Unit at Norwich.

The Center for Medium-Range Weather Forecasting (ECMWF), with a staff of 140, is a European organization established in 1973. Seventeen member states contribute to its $10.5 million annual budget. In *ESN* 37-9:365-366 (1983), James W. Daniel described the computational facilities at the center,

and a recent report in *Science* (Kerr, 1983) provides an overview of the Center's program. The Climatic Research Unit, a division of the School of Environmental Sciences at the University of East Anglia, has a staff of about 20 and emphasizes statistical studies of historical trends in the weather.

ECMFW

The ECMWF's objective is to develop numerical methods for medium-range weather forecasting (up to 10 days) to be distributed daily to the member states. Its program also includes research to improve forecasts, as well as rapid expansion of the data base.

The ECMWF predictions are based on a model of the physics of atmospheric and oceanographic circulation. Physical processes considered most important in the development and prediction of weather systems are differential heating, the distribution of land and water, topography, and the earth's rotations. In addition, their data matrix for the model includes current weather conditions (temperature, pressure, winds, and clouds) from 9000 weather stations around the world. Ocean weather ships, merchant fleets, aircraft flights, and weather satellites are also used. This immense data base, 80 million individual bits daily, is assembled every day as the basis for the ECMWF's forecasts.

Forecasts for up to 10 days ahead are prepared daily, based on the previous 24 hours of weather observations. A numerical forecasting model is used to predict the development of atmospheric systems, including North Sea storms, from the initial analysis through the next 10 days. The forecasting is based on the equations of motion, taking into account energy into and out of the atmosphere. There are two equations for the rates of change in the wind, one for the rate of change of temperature, and another for the changes in water and water vapor in the atmosphere. The model also takes into account both the frictional drag as the air passes over different surfaces and the modifications as air masses encounter obstacles such as hills and mountains. And since the rate at which moisture is transferred from the sea to the air is temperature-dependent, the model includes sea-surface temperatures. Following rain, when the earth's surface is very wet, moisture is transferred to the atmosphere almost as efficiently as from the ocean surface; and, when the surface is dry, the transfer may be from the air to the surface. All these states are included in the ECMWF model. To make a forecast, the model equations are solved so that from the analysis, the winds, temperatures, and moistures corresponding to a later time can be calculated. The new values are then used as the base for calculating the weather state for a later cycle. This process is repeated until the forecasts are no longer valid.

The grid used by ECMWF consists of 200-km spacing in the horizontal and 15 levels in the vertical. Since the analysis provides values of the meteorological elements at each grid-point, the density of the grid is important. Weather systems with a diameter of, say, 500 km, cannot be well represented within a grid with points more than 200-km apart; and rainfall and cloud systems require at least 10 grid points in the vertical for representation. The cost of increasing the density of grid points is high. A 100-km grid would, for example, quadruple the number of points and thus greatly increase the already high computational load on the ECMWF computer.

Another consideration is the interval between steps in the iterative procedure. The time between forecasts should be as long as possible to reduce the number of times that the procedure is carried out. But if the interval is too long, the computational errors grow so fast that the results quickly become useless.

The number of computer operations required for a weather forecast for 10 days is about 500 thousand million. To carry out the analyses, ECMWF uses one of the most powerful computing systems in the world, the CRAY-1 (*ESN* 37-9:365-366 [1983]).

But even CRAY-1 is actually too small and too slow for longer-term (10-day) forecasts. Therefore, ECMWF has installed a CRAY-X MP (expected to be operational in January 1984), which will increase the Center's computational power by 5-1/2 times. At present, the ECMWF model's forecasting skill (correlation with reality) is approaching 0.7 for 5-day forecasts, with 0.6 considered the minimum for useful applications.

The CRU

A major problem at the ECMWF is data-base development and data base management, and the atmospheric scientists at the Climatic Research Unit (CRU) at Norwich have a similar problem--data-base development. While the ECMWF deals with hundreds of millions of data bits, the climatologists at CRU go to extreme lengths to construct a single historical "weather map." Their problem is the need, always, for more information to improve their statistical analyses.

Prof. H.H. Lamb established the CRU several years ago and served as its director until 1977, when Prof. T.C.M. Wigley took the post. But based on Lamb's publication record over the past 5 years and his research plans for the next 5 years, one would never guess that he has "retired." Among the many projects he is working on is a study of storm activity in the North Sea.

The data collection process for Lamb's historical studies of climate involves the painstaking search for descriptions of weather conditions in ships' logs, reports on coastal flooding, newspaper accounts, and estate records. The research is time consuming and might take an investigator to the archives in Madrid to inspect the logs of the Spanish Armada, or to The Netherlands to review a city's report of flooding during the 17th century. The method used by Lamb and his colleagues at the CRU is to reconstruct the record of climatic conditions over as much of Europe and the North Sea as far back as possible, and in as much detail as the data permit. They then analyze that record to identify, if possible, sequences of events that may repeat through time. A 5-year effort might yield a record of 25 storms.

Lamb's interest in North Sea storms extends back many years. He completed a study in 1970 which showed that the frequency of wave heights greater than 3 m in the North Sea had increased significantly between the 1950s and 1970s, and later research suggested that this trend may have continued through the 1970s.

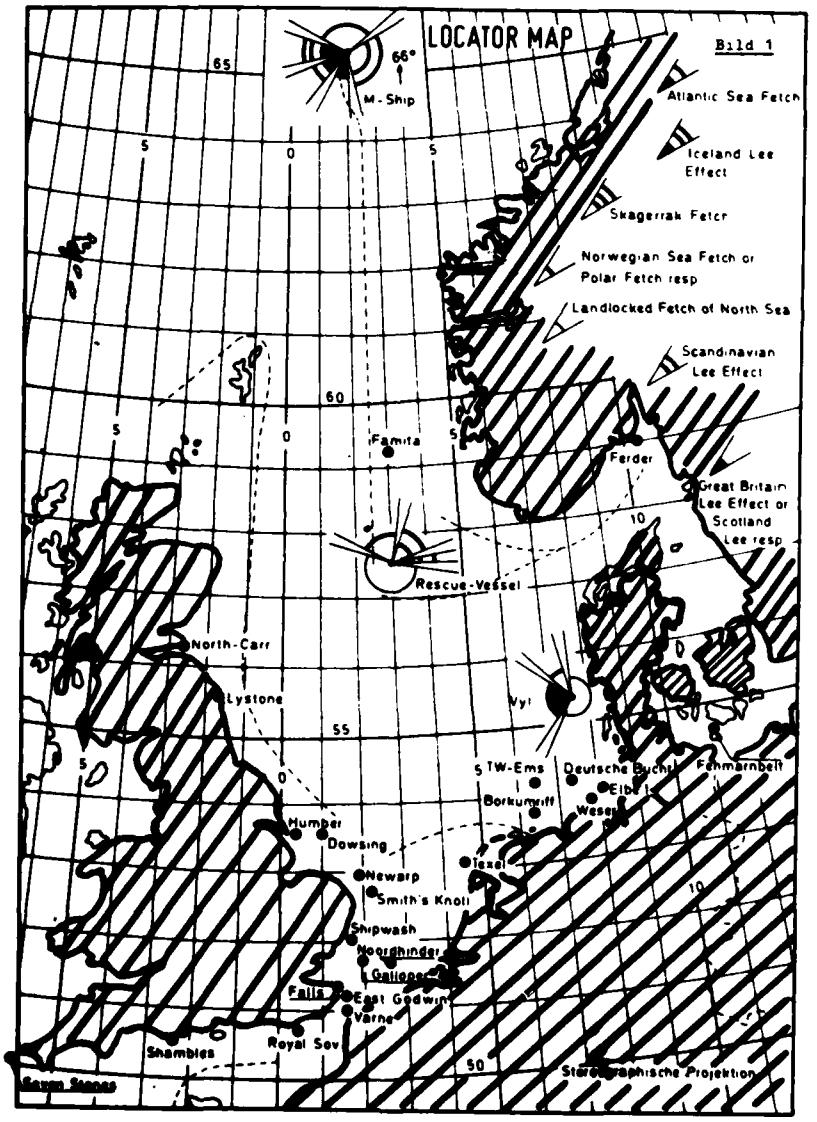


Figure 1. Measurements from lightships and weatherships.

Table 1

Summary List of Great Storms Analyzed Over the North Sea and British Isles Region

Strongest Winds
Estimates (E)
Observed (O)

Date	Areas Affected	Main Direction of Gale	Jet Stream	Gradient Wind Near Surface
14-18 Aug 1588	Northern North Sea off Scotland's E. coast and Northern Isles	SW	115-120 kt (E)	70 kt
21 Sep 1588	West Coast of Ireland	W	100-130 kt (E)	60-75 kt (E)
1 March 1791	Southermost part of North Sea, East Anglia and Kent	N-NNE		45-50 kt (O) sustained over 3 days
21-22 March 1791	Whole North Sea, especially western, southern, central and eastern parts	N and W		Up to 150 kt (O)
3-4 Feb 1825	Whole North Sea	NW		c. 120 kt (O)
14 Oct 1881	British Isles to North Sea, especially Ireland, southern and eastern Scotland, north-east England and central North Sea	-- (Cyclone Centre)		c. 80 kt (O) Surface winds up to Bft 11 (60kt) observed in eastern Scotland

Changes in the frequency of wave heights above 5 m showed a similar distribution.

Lamb's investigations showed that the change in North Sea storms had been associated with changes in the pattern of wind direction. Westerly winds have decreased over the area; and northwesterly and northly winds, which blow over long fetches into the North Sea, have increased in frequency since 1950 (Lamb, 1972). This trend has continued into the 1970s, though with more increase of the northwesterly winds and a slight decrease in the frequency of northerly winds (Lamb, 1981).

Following the publication of the 1970 results, Lamb was contracted by the Federal Republic of Germany (FRG) in 1977 to update his North Sea storm analysis, with particular emphasis on the operational areas of the FRG navy (Lamb, 1979). All available measurements from the lightships (German and British) in the operational area, as well as from oceangoing weather ships, were used in the research (Figure 1). This greatly increased the data base for Lamb's earlier investigation.

The simple graphic analyses (Lamb, 1979) show that, for all the British lightship locations, the trend toward increased wave heights continued during the 1970s, whereas for the German ship locations (in shallower water) the

Table 1 (Cont'd)

Gusts	Duration of Gale in Worst Affected Areas	Methods of Estimation	Remarks and Notes
c. 80 kt (E)	Probably 2 periods of about 24 hours	From speeds of travel of depression centres	Spanish Armada affected
75-90 kt (E)	About 20-24 hours	From speeds of travel of depression centres	Spanish Armada suffered main losses
c. 75 kt (E)	3 days over western-most North Sea; 12-24 hours in area of fiercest gale off Essex and Kent	Measured pressure gradients	Sea-flood up to Westminster
120-130 kt (E)	c. 2 days	Measured pressure gradients	Great sea flood near Hamburg
120-130 kt (E)	5 days	Measured pressure gradients	Sea flood from Holland to Denmark, probably the severest of the 19th century
80-90 kt (E)	A few hours	Measured pressure gradients	Violent sea off Eyemouth, Berwickskire coast, perhaps affected by waterspout (tornado-like) activity

results were less clear. It is also evident that the years with higher frequencies of high waves are not always identical with years of higher frequencies of high winds (storms); only during 1967, 1975, and 1976 do the peaks coincide.

To determine whether these patterns in North Sea storms had a longer-term trend, Lamb initiated a study of historical storms--that is, storms dating back to the 1600s. The research was supported by Shell Oil Company.

Countries surrounding the North Sea provide a rich historic record of weather and climate. For example, daily weather diaries have been kept in several countries from as early as the 14th century. These descriptions, along with monastic records, ships' logs, estate papers, and personal correspondence are collated by Lamb to give a weather report and to construct a weather map. Although his analyses of the data are incomplete, Lamb has prepared a report (as yet unpublished) of severe storms in the North Sea (Lamb, 1982).

Most of the great storms included from earlier times are traced through records of the severity of the sea flooding of low-lying coastal areas. Lamb said that this method may result in missing a few storms. Other storms have

come to light through the severity of the reported damage on land, damage to coasts, and the number of shipwrecks.

Lamb's catalogue so far includes the following severe storms: two cases each for the 16th through the 19th centuries, two from 1900 to 1950, and 13 from 1950 to 1981. Table 1 is an example of the summary listings in this as yet unpublished catalog.

Lamb notes that storms in the North Sea have shown an increase in frequency, with some of the severest cases occurring in recent years. This trend is expected to continue for the next 100 years, or for as long as the westerly and southwesterly winds of the North Sea area remain below their 1900 to 1954 frequency. He stressed, however, that severe storms will still be exceptional events.

But how reliable are predictions based on a data set of 25 to 50 storms spanning 500 years? This is not an academic question. The FRG was interested in the results because of a trend toward increased repair costs to their coastal lightships and patrol boats, and Shell Oil Company is obviously interested because of concern for North Sea drilling and production rigs that may cost over $1 billion each.

To answer this question, and to add a degree of caution to his own predictions, Lamb pointed out that in the early 1970s a World Meteorological Working Group reviewed some two dozen predictions concerning the course of climate over the coming 20 to 50 years. The forecasts were close to unanimous (Lamb, 1977). "The cooling which...has affected the Northern Hemisphere over the previous 30 years...is likely to continue." Although there might be the occasional brief respite, there were few indications that the cooling would end until the 21st century.

But in 1978, the US National Defense University (Washington, DC) surveyed the opinions of the world's leading climatologists: What will our climate be like in the early 21st century? The consensus, although not unanimous, favored warming. The earlier predictions of cooling were based on statistical analyses of long climatic records for evidence of cycles or trends--and these, when found, were extrapolated into the future. At the same time as climatologists were updating the data that eventually revealed the warming of the 1970s, scientists concerned with the physics of the atmosphere were re-evaluating a claim made in the 19th century that the increase in atmospheric carbon dioxide caused by deforestation and the burning of fossil fuels would lead to global warming. It is now accepted among the climatological community that rising atmospheric carbon dioxide levels will produce a significant climatic change in the near future. According to the climatologists at the CRU, the best estimate is that the "greenhouse" effect will result in a global temperatures rise of 2 to 3°C. Whether this will greatly alter the trend in North Sea storms remains a debatable question that Lamb expects to ask at a North Sea storm workshop sometime next year.

References

Kerr, R.A., "The Race to Predict Next Week's Weather," *Science*, 220 (1 April 1983), 39-41.

Lamb, H.H., *British Isles Weather Types and a Register for the Daily Sequence of Weather Patterns 1861-1971*, Geophysical Memoirs No. 116 (London: Her Majesty's Stationery Office, for Meteorological Office, 1972).

Lamb, H.H., *Catalogue of Great Storms Reported in the North Sea and Neighboring Regions* (Climatic Research Unit, 1982).

Lamb, H.H., *Climate: Present, Past, and Future*, Vol 2 (London: Methuen, 1977).

Lamb, H.H., "Climatic Fluctuations in Historical Times and Their Connexion With Transgressions of the Sea, Storm Floods and Other Coastal Changes, in *Transgressies en Occupatiegeschiedenis inden Kustgebieden van Nederland en Belgie*, ed. A. Berhulust and M.K.E. Gottschalk (Ghent, Belgium: Rijksuniversiteit, 1981), 251-290.

Lamb, H.H., and I. Weiss, "On Recent Changes of the Wind and Wave Regime of the North Sea and the Outlook," *Fachliche Mitteilungen*, 194 (1979).

11/22/83

ELECTRONICS

FIFTH INTERNATIONAL CONFERENCE ON THE ELECTRONIC PROPERTIES OF TWO-DIMENSIONAL SYSTEMS

by J.T. Schriempf. Dr. Schriempf is Superintendent, Condensed Matter and Radiation Sciences Division, Naval Research Laboratory, Washington, DC.

A two-dimensional electron system is, in its pure form, only a theoretical

concept. Experimental approximations exist in a number of media, however, with classical examples being electrons on the surface of liquid helium and at the semiconductor-oxide interface of a silicon metal-oxide-semiconductor field effect transistor (MOSFET).

Obviously, the correct study of the intrinsic properties of a two-dimensional system depends critically on the degree of which the experimental structure approximates the ideal concept. All the systems used consist of a layer of electrons kept in place by a host, and the interactions with the host must be minimized. The periodic potential of the host affects the electron layer, but theoretical schemes deal very effectively with this and are not a problem. Major concern focuses on random (in contrast to periodic) fluctuations in the potential which maintains the electrons in their place--for these fluctuations produce scattering and a finite scattering time or, conversely, limit the mobility of the electrons.

The Fifth International Conference on the Electronic Properties of Two-Dimensional Systems, hosted by the Clarendon Laboratory, was held in Oxford, UK, from 5 through 9 September 1983. These conferences have been held biannually since the first at Brown University in 1975. They have grown substantially--from about 50 attendees in 1975 to over 200 at the Oxford meeting. The conferences have reflected the continuing progress in two-dimensional systems. For example, during the past 5 years modulation doping, in combination with molecular beam epitaxy (MBE), has permitted generation of two-dimensional electron systems at the junction between two III-V semiconductor materials. Here the electrons are bound to a lattice-matched interface between two crystalline materials. Mobilities as high as 10^6cm/Vs and beyond have been achieved, which means scattering times of 5×10^{-11} s and a mean free path of 5μm for an elastic event. These materials have had an enormous impact on the development of the fundamental understanding of two-dimensional electron systems, as indeed they also have affected the semiconductor industry.

To this observer, it appears likely that over the next several years the continued development of MBE and other techniques will be a very productive source of new materials, both for fundamental studies and technological applications. Single and multiple layers of atomically smooth and arbitrarily selected thicknesses are being made for semiconductors and for magnetic and metallic materials. It may be that experts such as those at this conference will join with the magnetic and metallic thin film specialists in the near future. An invited paper by M. Pomerantz on two-dimensional magnetic materials was the only discussion specifically on magnetic systems, but I hope it points toward increased interaction between the semiconductor, magnetic, and metallic system specialists in two-dimensional materials.

It is impossible to present a reasonable digest of such a full meeting; this article briefly indicates the scope of the topics discussed. For more detailed information, see the proceedings, which will be published in a special issue of *Surface Science*--scheduled for spring 1984. Previous conference proceedings appeared in volumes 58, 73, 98, and 113.

Quantum Hall Effect and Anomalous Quantum Hall Effect

The most exciting work reported at this meeting--and perhaps the main thrust of the conference--was the recent discovery of the "fractional quantization of the Hall effect" by H.L. Stormer and coworkers. At the fourth conference on electronic properties of two-dimensional systems in 1981, there was excitement about the discovery of the quantum Hall effect, wherein the Hall resistivity ρ_{xy} exhibits quantized plateaus in its magnetic field dependence. At the field positions where the Hall resistance assumes its quantized values $\rho_{xy} = h/ne^2$, $(n = 1, 2, 3,...)$ the diagonal resistivity ρ_{xx} goes to zero as the temperature approaches zero. The precision of the quantization has been established to better than one part in a million. This quantization is understood in terms of full Landau levels in an ideal two-dimensional system with no disorder. The importance of, and interest in, this quantized Hall effect is illustrated by the selection of a stylized version of the ρ_{xy} versus magnetic field data showing the quantized levels as the logo for this conference.

It is apparent that the fractionally quantized data just reported is challenging the theorists in this field. After admitting that the simply quantized effect was totally unpredicted, and having just worked out an understanding of it, they are now scrambling to understand the fractional effect. In the fractional effect, plateaus are observed in the magnetic field dependence

of $\rho_{xy} = h/(\nu e^2)$, where $\nu = p/q$, $q = 3,5,7$, and p takes on all integer values. Plateaus have been observed at $\nu = 1/3$ and 2/3 to better than a few parts in 10,000. Minima in ρ_{xx} have been observed at $\nu = 1/3$, 2/3, 4/3, 5/3, 2/5, 3/5, 4/5, and 2/7.

Theoretical work on the fractional quantum Hall effect is still very much in a state of flux. Perhaps the best progress to date was presented by R.B. Laughlin. His theory involves a liquid-like model in which the fractionally charged quasiparticles associated with the effect are fermions. In addition to explaining the 1/3 and 2/3 states, he put forward wave functions for the 2/7 and 2/5 states.

Other Topics

While there was much interest in the Hall effect, the conference also dealt with other topics; these are summarized below.

One Dimensional Conductance in Silicon MOSFETs. It is inevitable that scientific curiosity would extend below two-dimensional effects to one-dimensional effects and their possible realization in physical systems. It is apparent that this is still a challenge, although many interesting results have been obtained.

Weak Localizations and Interaction Effects. Localization is central to many of the physical phenomena observed in two-dimensional electronic systems.

New Two-Dimensional Electron Gas on the Surface of Solid Neon. For some years the two-dimensional electron gas has been experimentally approximated by electrically confining electrons on the surface of a liquid helium film on a very smooth substrate. A new development was reported at the conference: the electron layer is formed on the surface of solid neon.

Magnetization, Specific Heat, and Thermomagnetic Phenomena. Landau quantization of the two-dimensional gas by a magnetic field gives rise to a number of novel effects, most notably the quantum Hall effect discussed earlier. Strong oscillations in the thermoelectric power were reported by a number of workers.

Two-Dimensional Plasmons. Many workers, both theoretical and experimental, approach the two-dimensional electron gas from the plasmon point of view. The excitations of these collective modes give rise to a number of interesting effects, including infrared emission effects.

Electron-Phonon Interactions and Screening. The transport behavior of a two-dimensional electron gas is strongly controlled by electron phonon interactions and screening effects. A number of papers on this aspect of these systems were presented.

Doping Superlattices: n-i-p-i. Several workers presented results on "multiple layer" two-dimensional electron gases which are constructed by variously doping layers of III-V or IV-VI semiconductors to form layers in the following order: n-type, intrinsic, p-type, intrinsic, and so on.

Optical Studies. Of particular interest was the study of absorption and luminescence of superlattices built up from III-V semiconductor compounds.

Devices. Devices and device applications were discussed by a few workers. Included were opto-electronic effects and high speed hetero-structure assemblies. Interest was especially keen in the AlInAs/GaInAs and InP/GaInAs systems. It is anticipated that in these systems the two-dimensional electron gas would lead to a 50-percent improvement in speed--compared with other devices currently in use--and a factor-of-two reduction in power consumption at room temperature. This would require substantial improvements in crystal growth and device fabrication technology.

11/23/83

ENGINEERING

UNDERWATER ACOUSTICS RESEARCH AND DEVELOPMENT AT THE UNIVERSITY OF BIRMINGHAM

by Chester McKinney. Dr. McKinney is the Liaison Scientist for Underwater Acoustics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from The University of Texas at Austin, where he is Senior Research Scientist at Applied Research Laboratories.

For many years the University of Birmingham (UK) had the distinction of having the only engineering department (Electronic and Electrical Engineering) in which underwater acoustic research and sonar engineering was the major field of interest. The department still has a good program in acoustical research and engineering, but I must

report that the academic staff has shrunk to six members--about half the one-time total.

The activity at Birmingham was initiated by Prof. D.G. Tucker about 25 years ago; he rapidly expanded the annual student influx from about 20 to 120 and ultimately increased the faculty to include four professors (not all in acoustics). The reduction in staff is due to a combination of two factors. First, Tucker retired, and over several years a number of the academic staff left to assume positions elsewhere (often as heads of departments). This factor alone would be considered normal and a reflection of the quality of the Birmingham program. Unfortunately, during this same period university budgets have become increasingly tight, and academic positions often have not been filled as they have become vacant through retirement, death, and resignation. At present the department has no professor of acoustics, and this is not a comfortable situation for the other faculty members who specialize in that field.

Post-Experience Teaching

There has been an important expansion in the teaching activities of the acoustics group. The staff has developed an intensive 2-week course in underwater acoustics and sonar engineering which has become very popular and is a significant effort of the department. This course, presented most frequently under the sponsorship of the Admiralty Underwater Weapons Establishment (AUWE) and Plessey Marine Research Center, was first given in 1974 and currently reaches about 100 students each year.

The course content and level are planned for scientists and engineers who have a first degree and are working in the field of sonar, but have limited experience in the subject. The course covers the usual topics of propagation, transducers, signal processing, arrays, and system design and uses a special text developed by the staff for the course. Enrollment is limited to 36 per class. The schedule includes 50 hours of lectures and demonstrations plus nine 1-hour tutorials. The fee is £350. The Birmingham course, which appears to be similar to some US continuing education courses, probably is serving a valuable role in improving the quality of underwater acoustics research and development in the UK.

Relations With Industry and Government Establishments

From recent visits to several UK universities it is evident that the government is placing a strong emphasis on turning scientific research into technological developments and then into industrial production. Certainly this theme was pervasive at Birmingham. The acoustics group has support from Ministry of Defence establishments (e.g., AUWE), the Science and Engineering Research Council, the Department of Agriculture and Fisheries, and several companies. They also were one of several UK universities to receive a one-time block grant from the Wolfson Foundation (in 1979), specifically to aid in interfacing their university R&D with the needs of government and industry. The Wolfson support is used primarily to provide additional facilities and capabilities for transducer work. In fact, much of the extramural support relates to developing special transducers and, in some instances, producing such devices in modest quantities. For example, last year the university sold £25,000 of transducers to a single UK company. In another instance, the group is providing sonar consulting and testing and calibration services to a company which has extensive capability in polyvinylidene difluoride materials but little experience with electroacoustic transducers. There are evident civil and naval applications for all the current projects. Limitation to the size or growth of projects for government and industry is due more to the size of the staff and number of graduate students rather than to any lack of extramural support.

Research Program

On my recent visit to the University of Birmingham, Dr. David J. Creasey, Mr. J.R. Dunn, Mr. P.D. McQueen, and Dr. Brian K. Gazey briefed me on several of their projects in propagation, transducer development, and signal processing.

A recently completed project dealt with a theoretical and experimental study of the scattering of sound from the sea surface using a high-frequency, high-speed scanning sonar. Initially the experimental work was being done at the group's Belvide Reservoir Field Station but was terminated when winter ice buildup destroyed the facility. The work was then completed in the Birmingham large concrete-wall laboratory tank. They obtained reasonable agreement between theory and experiment.

One of the current major projects is aimed at measuring the average particle size and variation of bottom gravel and mineral nodule deposits. This project has obvious commercial application. Considerable theoretical

work, computer modeling, and experimental work has been done. The scheme involves the use of a high-frequency, wide-bandwidth (500 kHz±100) sonar to measure the backscattered energy. These data are then converted to power spectra from which first through fourth order statistics are calculated. Early work was promising when the bottom material was composed of particles of uniform size but not when using natural gravels where there was a fairly wide distribution of sizes. They are optimistic that useful results can be obtained by using the data to calculate kurtosis (i.e., the fourth moment minus the square of the variance), which is related to the average particle size. Again, the method is likely to work best when the size distribution is not too broad.

Other work in this general area includes a study of low frequency noise generated by a water current flowing past a moored hydrophone. A related piece of work involves the propagation of noise over a discontinuity in depth. Another project involved the measurement of source level in the presence of multiple propagation paths.

In an earlier period the group did considerable work for the Department of Agriculture and Fisheries, using a high-frequency, high-resolution, scanning sonar to make measurements of the density of fish in schools. The techniques are fairly conventional for the case of low densities, where multiple scattering is not important, but fail for very dense schools. Current work is aimed at using higher order statistics to extract the information from a measure of the total acoustic cross section.

Much of this work is being done by the UK's fisheries laboratories, with Birmingham primarily providing support in developing wide-bandwidth transducers and standard sonar calibration targets. The general scheme is to use a downward-directed echo sounder to detect schools of fish. If quantitative data are to be realized, it is essential to use either a precisely calibrated sonar or a standard (comparison) target suspended below the sonar at approximately the same range as the schools of fish. The latter option has recognized advantages, but it is necessary to have a precise calibration of the standard target.

The Birmingham group has expended considerable effort to develop such targets. Initially they attempted to use ping-pong balls, which are inexpensive and readily available, but tests revealed excessive variability among samples and also undesirable resonances near the typical operating frequencies (e.g., 38 kHz). They are now working with tungsten carbide spheres (38-mm diameter); these seem to be much more suitable, having resonances well above the band of interest. However, even with these targets they find small but measurable differences between spheres made during different production runs.

It is an old Birmingham in-house joke that if a student wanted to get an advanced degree he had to invent at least one new type of fast scanning sonar. Certainly the acoustics group has made contributions in that subject, and such work continues to be done. Most of the current work centers on using standard and special charge coupled devices (CCDs) to effect the equivalent of fast-phase-shift beam scanners. The aim is to use the latest in fast electronic devices to make it possible to scan fractional degree beams over a wide sector (e.g., 30 degrees) within the pulse duration of a few microseconds, while retaining a wide dynamic range. Initial work was done using a variable clock frequency and nonlinear distribution of taps on the CCDs, but this was not satisfactory. Next the researchers devised a scheme using CCDs to perform a spatial Fourier analysis, using the Chirp Z transform. With this they can scan a 32-element, 500-kHz array at the rate of about 1.0 degree per microsecond; they believe this speed can be increased by a factor of four. The dynamic range, including compression, is about 100 dB. The present device employs four CCD units. High scanning speed is especially necessary if one is to scan, in both azimuth and elevation, a narrow beam over a wide sector.

The technology used in the beam scanner (spatial Fourier analysis) has been applied with considerable success in the time domain for Doppler resolution. This can be done either with a variable clock frequency or nonlinear spacing of CCD taps.

Correlation techniques are also being employed on a device to measure speed over the bottom. The scheme is basically the Dickie-Edward arrangement, in which there is a downward-directed transmitting beam and a set of similarly directed receiving beams. The receiver outputs are cross-correlated, with the peaks in the correlation patterns being related to the speed over the ocean floor. The spacing of the elements must be known with high precision. The present system operates at 20 kHz, using two closely spaced pulses, and is expected to work for water depths from 6 to 200 m. The aim is to achieve 1.0 percent accuracy in speed measurements.

Another signal processing project involves the development of a synthetic aperture side-looking sonar. This work is in a very early stage of hardware development.

A considerable portion of the total Birmingham program involves the development of various types of transducers for a number of internal projects and for outside sponsors. Several of the projects require transducers with fairly wide bandwidths, and several interesting designs have evolved. One unit, which has a bandwidth from 350 to 600 kHz, is a multilayer piston unit with the following sequence of elements: water, $\lambda/4$ impedance matching plate of epoxy and aluminum powder mixture, $\lambda/2$ piezoelectric element (surrounded on the sides with flyash-epoxy pressure release material), $\lambda/4$ epoxy plate, $\lambda/4$ steel plate, a thick (several λ) base of flyash, and epoxy. This type of unit can be used at great depths and has a respectable bandwidth. The researchers are investigating anisotropic materials for backing plates to minimize certain unwanted resonances and reduce mode coupling. They are also investigating the use of auxiliary piezoelectric units (nonradiating) to give increased bandwidths. A study of transducer aging is also under way.

One interesting project is to develop the transducer for a small scanning sonar that can be lowered down a borehole to inspect abandoned mines which are probably flooded.

Although the underwater acoustics program at Birmingham is smaller than in the past, it still comprises a number of interesting research and development projects. This work and the program in post-experience teaching and industrial consultation combine to form an influential entity in UK underwater acoustics.

11/9/83

MATERIAL SCIENCES

METALLURGY AT THE RISØ NATIONAL LABORATORY, DENMARK

by R.W. Armstrong. Dr. Armstrong, formerly at ONR, London, is on sabbatical leave from the University of Maryland for the 1984 spring term as Visiting Fellow, Clare Hall, University of Cambridge, UK.

The Metallurgy Department, Risø National Laboratory (DK-4000 Roskilde, Denmark), is concentrating on general materials research, technology and materials development, fuel elements, and international collaboration, including education and training projects (Hansen, 1983b). Dr. Niels Hansen is head of the department, which includes a scientific staff of 35 researchers and a somewhat larger number of supporting staff. This article focuses on the department's work with polycrystal strength properties, fracture mechanics testing, composite materials, energy storage materials, battery-related research, and nondestructive testing.

General Materials Research

Hansen and colleagues have done pioneering research on the grain size dependence of the stress-strain behavior of polycrystals--particularly aluminum (Hansen, 1983a) and copper (Hansen and Ralph, 1983) materials. Figure 1 is from an electron microscopy investigation of deformation structures in polycrystal aluminum, done in cooperation with the Danish Academy of Engineering, by Hansen and Bay (1982). An assessment of the slip bands meeting at the grain boundaries showed that in about 20 percent of such cases, the slip-band strain in one grain appeared to penetrate a short distance into the adjacent grain. Currently, R.A. Jago is at Risø, from Monash University (Melbourne, Australia); he hopes to follow up this work with Hansen and B. Ralph by correlating more definitely the replicated slip-band structures with slip-band dislocation density measurements made by transmission electron microscopy (TEM) both far from and near to grain boundaries. TEM images of carefully thinned specimens have been obtained to show both slip-band traces and internal dislocation arrangements. Hansen proposes that measurement of the two dislocation densities, within the grains and at the boundaries, will probably correlate better with the flow stress dependence on polycrystal grain size, normally described by the Hall-Petch relation.

On a Hall-Petch basis, for example, thin slip bands tapering to a knife edge at the boundary are interpreted to depict dislocation pile-ups not broken through the grain boundary obstacle. But bands whose primary pile-up strain has already been transmitted are distinctly recognizable: they are long and wide, either joined across a boundary or apparently penetrating the adjacent grain (Armstrong, 1983). The full displacement of the accommodated wide band is a measure of the number of dislocations generated from within a grain once the grain boundary obstacle

Figure 1. Electron microscope replicated (white and dark) slip-band step-height structures meeting at a grain boundary (dotted line) on the surface of polycrystalline aluminum of 99.998 percent purity, cold-rolled to 15-percent strain.

has been surmounted. In this way, short segments of "penetrated" slip give a measure also of the greater slip-band strain following pile-up breakthroughs at the various positions along a boundary.

Hansen and Ralph, who is at the University of Cambridge, have investigated the additivity of particle bowing stresses, mean back stresses, and matrix work hardening stresses to the Hall-Petch equation for alumina particle strengthening (in the range 0.41 to 1.81 volume percent alumina) of polycrystalline copper. Lilholt (1983) has investigated the rules of addition for such dispersion-hardened materials. Also at Risø, T. Leffers and O.B. Pedersen (1982) have investigated polycrystal strengthening from the viewpoint of separating grain-size independent and dependent terms according to the pattern of slip within the material. Most recently, Pedersen (1983) has extended the work to consider the thermoelastic and plastic deformation behavior of composite materials.

The fatigue, creep, and irradiation damage properties of the same copper and aluminum materials are of interest. The texture of grain orientations is an important consideration for determining the plastic flow properties of different polycrystal grain size materials; Juul Jensen and Kjems (1983) have developed a new neutron-diffraction apparatus for making dynamical texture measurements. The apparatus incorporates a linear position-sensitive (proportional gas) detector which allows a quarter of a complete pole figure to be determined in 15 minutes with an accuracy of 2 to 3 percent. Recrystallization and grain growth studies have been completed for pure copper and aluminum-.016 volume percent alumina.

One measure of the high international standing of the foregoing metallurgy and materials science research activities is afforded by the four annual Risø symposia, which have dealt with topics such as recrystallization and grain growth (1980) deformation of polycrystals (1981), fatigue and creep of composite materials (1982), and deformation of multiphase and particle-containing materials (1983). The Fifth Risø International Symposium on Metallurgy and Materials Science, entitled "Microstrutural Characterization of Materials by Non-Microscopical Techniques," is scheduled for 3 through 7 September 1984. Among the preliminary list of keynote speakers is D.K. Bowen (University of Warwick, UK) on the topic "Application of Synchrotron X-ray Methods for the Characterization of Deformed and Recrystallized Microstructures" (see *ESN* 36-12:334-338 [1982]). The subject is important because Risø is a potential site for the European Synchrotron Radiation Facility (ESRF) being considered for development by the European Science Foundation (see *ESN* 37-6:226-227 [1983]).

Technology and Materials Development

Dynamic fracture toughness testing, acoustic emission during deformation and

fracture processes, and irradiation embrittlement of weldments in steels for nuclear-reactor pressure vessels are research topics undertaken in cooperation with the UK Atomic Energy Authority, the Nuclear Agency of the Organization for Economic Cooperation and Development, and the International Atomic Energy Agency (IAEA). Debel and Adrian (1983) have reported direct current-potential difference (DC-PD) measurements of ductile crack growth in connection with the fracture mechanics testing of A533B, BS1501-281A, and BS4360-Gr50D steel materials. Adrian, Chatterjee, and Debel (1983) have reported fracture mechanics measurements of weldments from unirradiated French, German, and Japanese steel materials as a prelude to investigating their irradiation embrittlement properties. The work is part of an IAEA program called "Analysis of the Behavior of Advanced Pressure Vessel Steels Under Neutron Irradiation."

H. Lilholt and A. Lystrup have undertaken a development project to produce glass-fiber-reinforced polyester wing-blades for small and medium-size wind turbines. The project involves local industry, electricity generating companies, and the Ministry of Energy. Lilholt worked previously with metal composites and has reported on some aspects of the more recent work (Lilholt, 1982). Current studies are concerned with additional mechanical property measurements, control of manufacturing, and test procedures relating to the design and fabrication at Risø of 12-m wing-blade sections for the Nibe wind turbines. A computer-controlled tape winding apparatus has been developed.

Energy storage research at Risø has been concerned with the reversibility of hydride formation and decomposition in magnesium or iron titanium, FeTi, powders. Both systems are candidates for automotive power. In contradiction of earlier work, the cyclic hydrogenation of unalloyed Mg seems to work well. Reversibility has been maintained over 70 thermal cycles involving high temperature exposure at 400°C for 1200 hours (Vigeholm, Kjøller, Larsen, and Pedersen, 1983). For FeTi-H_2 and D_2 (deuterium) systems, the equilibrium adsorption isotherms have been determined at 78 to 88°K and for FeTi-H_2, at 293 to 473°K (Pedersen, Møller, and Toft Sørensen, 1983).

Solid electrolytes and lithium electrodes are topics being investigated in research on rechargeable lithium batteries. Previous work by F.W. Poulsen and colleagues was concerned with proton-conducting solids for fuel cell development, thermophysical property measurements in fluorites and structurally related compounds, and neutron scattering studies of materials such as LiI-D_2O and $Li_{1.6}Ag_{0.4}SO_4$. Current work has involved fast-ion conduction in electrolytes such as $LiBiO_2$ (Andersen, Poulsen and Eichinger, 1983); LiI-Al_2O_3 composites (Poulsen, Andersen, Kindl, and Schoonman, 1983); and solid lithium-based sulphates (Aronsson, Knape, Lundén, Nilsson, Torell, Andersen, and Kjems, 1983). Electroplated LiAl anodes are being developed for reversible batteries.

Fuel Element Testing

H.E. Gundtoft, T. Nielsen, and colleagues have developed over a period of about 10 years an ultrasonic water-immersion system for the nondestructive inspection of dimensions and flaws in precision fuel tubing (Figure 2). Further work has involved the development of a second automated hydraulic ultrasonic testing unit with a computerized PDP 11 scanning system dealing with five degrees of freedom (Gundtoft, 1983). The leading-edge crack profile of a fracture mechanics compact tensile specimen has been resolved to about 0.1 mm. Full three-dimensional characterization of the ultrasonic sound field is obtained with the equipment.

References

Adrian, F., S. Chatterjee, and C.P. Debel, *Irradiation Embrittlement of Weldments in Pressure Vessel Steels*, Metallurgy Department Report, Risø-I-121 (1983).

Andersen, N.H., F.W. Poulsen, and G. Eichinger, "Conductivity, Structure, and Specific Heat of $LiBiO_2$," *Studies in Inorganic Chemistry*, 3 (1983), 287-290.

Armstrong, R.W., "The Yield and Flow Stress Dependence on Polycrystal Grain Size," in *Yield, Flow and Fracture of Polycrystals*, ed. T.N. Baker (Applied Science Publishers Ltd., 1983), 1-31.

Aronsson, R., H.E. Gunilla Knape, A. Lundén, L. Nilsson, L.M. Torell, N.H. Andersen, and J.K. Kjems, "Solid Sulphate Electrolytes: The First Examples of a Strange Ion Transport Mechanism," *Radiation Effects*, 75 (1983), 79-84.

Debel, C.P., and F. Adrian, *Experience With Ductile Crack Growth Measurements Applying the DC-PD Technique to Compact Tension Fracture Specimens*, Metallurgy Department Report, Risø (1983).

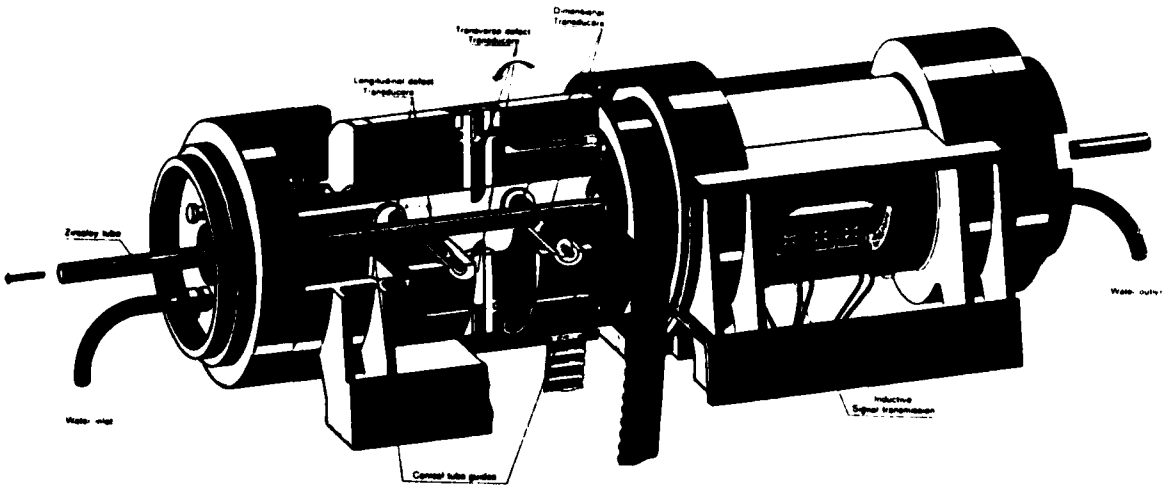


Figure 2. Ultrasonic transducers within a rotating water chamber (maximum speed 3000 rpm) with PDP 8 computer read-out.

Gundtoft, H.E., *Automatic Quantitative Non-Destructive Examination in a Computerized Scanning System (5 Degrees of Freedom)*, Risø-M-2391 (1983).

Hansen, N., "Flow Stress and Grain Size Dependence of Non-Ferrous Metals and Alloys," *Yield, Flow and Fracture of Polycrystals*, ed. T.N. Baker (Applied Science Publishers Ltd., 1983a), 311-350.

Hansen, N., *Metallurgy Department Progress Report for 1982*, Risø-R-486 (1983b).

Hansen, N., and B. Bay, "Microstructures and Deformation Mechanisms in Polycrystalline Aluminum," in *Strength of Metals and Alloys* (ICSMA 6), ed. R.C. Gifkins (Pergamon Press, 1982), 401-406.

Hansen, N., and B. Ralph, "Additive Strengthening in Copper-Alumina Alloys," in *Deformation of Multi-Phase and Particle Containing Materials*, ed. J.B. Bilde-Sørensen, N. Hansen, A. Horsewell, T. Leffers, and H. Lilholt (Risø National Laboratory, 1983), 285-293.

Juul Jensen, D., and J.K. Kjems, "Apparatus for Dynamical Texture Measurements by Neutron Diffraction Using a Position Sensitive Detector," *Textures and Microstructures*, 5 (1983), 239-251.

Leffers, T., and O.B. Pedersen, "The Strength of Polycrystals," in *Strength of Metals and Alloys* (ICSMA 6), ed. R.C. Gifkins (Pergamon Press, 1982), 75-82.

Lilholt, H., "Advanced Fiber Reinforced Plastics," *Composite Materials* (Copenhagen: Teknologirådets Kompositmaterialeudvalg, 1982), 33-44.

Lilholt, H., "Additive Strengthening," in *Deformation of Multi-Phase and Particle Containing Materials*, ed. J.B. Bilde-Sørensen, N. Hansen, A. Horsewell, T. Leffers, and H. Lilholt (Risø National Laboratory, 1983), 381-392.

Pedersen, A.S., P.J. Møller, and O. Toft Sorensen, "A Kinetic and Thermodynamic Study of the Reaction of Hydrogen and Deuterium With FeTi at Low Pressures," *Berichte der Bunsen-Gesellschaft für Physikalische Chemie*, 87 (1983), 104-112.

Pedersen, O.B., "Thermoelasticity and Plasticity of Composites--I. Mean Field Theory," *Acta Metallurgica*, 31 (1983), 1795-1808.

Poulsen, F.W., N. Hessel Andersen, B. Kindl, and J. Schoonman, "Properties of LiI-Alumina Electrolytes," *Solid State Ionics*, in press.

Vigeholm, B., J. Kjøller, B. Larsen, and A.S. Pedersen, "Hydrogen Sorption Performance of Pure Magnesium During Continued Cycling," *International Journal of Hydrogen Energy*, 8 (1983), 809-817.

11/29/83

SECOND INTERNATIONAL CONFERENCE ON COMPOSITE STRUCTURES

by R.W. Armstrong.

The Second International Conference on Composite Structures (ICCS/2) covered theoretical aspects and practical applications of structural composite materials for all types of engineering uses. The conference, following up on ICCS/1 in 1981, was held from 14 through 16 September 1983 at Paisley College of Technology (PCT), Paisley, Scotland, in association with the Scottish Development Agency and the National Engineering Laboratory, East Kilbride. For an overview of composite materials research in the UK, see T.-W. Chou's series of articles in *ESN* 37-4 through 37-12 (1983).

The 104 conference registrants from 21 countries were mostly composite users, manufacturers, designers, and engineering researchers. I.H. Marshall, Department of Mechanical and Production Engineering, PCT, was Conference Director and edited the 566-page proceedings: *Composite Structures 2* (Applied Science Publishers, Ltd., 1983). Marshall is editor also of the new journal *Composite Structures*, begun in July 1983 by Applied Science Publishers (see *ESN* 37-5:190-191 [1983]).

Two plenary lectures were given at the start of ICCS/2. A.R. Bunsell (École Nationale Supérieure des Mines de Paris, Centre des Materiaux, 91003-Evry, France) described the monitoring by acoustic emission of cumulative damage in strained carbon fiber reinforced plastic (CFRP) resin structures. M.J. Owen (University of Nottingham, Department of Mechanical Engineering, Nottingham NG7 2RD, UK) reported on a completed study of glass reinforced plastic (GRP) material strength properties under biaxial stressing.

Bunsell claimed that acoustic monitoring, with all its difficulties, is the best method for monitoring damage in CFRP structures. Analysis of emission amplitudes now offers the best method of detecting fiber fractures, matrix cracking, and interfacial debonding. The Kaiser effect of a previously stressed material generating further acoustic emission only after the earlier maximum stress has been exceeded is almost always observed. According to Bunsell, proof testing or minimum life prediction techniques based on acoustic emission monitoring of CFRP material are now thought to be feasible.

Bunsell and D. Valentin (1983) have reported success on reproducing and quantifying irreversible damage in carbon fiber reinforced epoxy resin plate material subjected to prolonged steady loading. These results and others on cyclic loading were described at the conference by Valentin. Other papers on structural monitoring were by J.C. Duke, Jr., E.G. Henneke, W.W. Stinchcomb, and K.L. Reifsnider (Virginia Polytechnic Institute and State University [VPISU], Blacksburg) on a pulsed ultrasonic "stress wave factor" technique, and by P.T. Cole (Endevco UK Ltd., Herts. SG8 6AQ, UK) on applications of acoustic emission to aerial booms for man-lifting and to petrochemical tanks. J.N. Leckenby and P.S. Gill (Dupont Ltd., Stevenage, UK) reported on the commercial development of a dynamic mechanical analyzer electromechanical system for complex modulus measurements. The system has been used to determine the degree of cure and mechanical stability of aramid epoxy composite systems, epoxy glass laminates, and graphite-epoxy prepreg materials.

In the second plenary lecture, Owen made sense of the more than 40 (stress-state) failure theories previously proposed for anisotropic metals, wood, reinforced plastic, and similar materials. His project was supported in part by the naval branch of the UK Ministry of Defence. The difficulty with very heterogeneous materials is that there may be multiple failure mechanisms, and there is always a definitional problem of specifying structural failure versus material failure. Results on unidirectional, fabric-reinforced, and chopped-strand-mat GRP materials were presented. Modified combined stress and distortional energy theories, previously developed by Norris for wood materials, were judged to be most suitable for fabric laminates--whereas principal stress theories, with reference tensile and compressive strengths, were proposed for essentially plane isotropic chopped-strand-mat GRP materials. R. Girard (Office National d'Etudes et de Recherche Aerospatiales, 92322-Chatillon, France) reported similar results. He analyzed the results on the basis of a generalized Reissner homogeneous plate theory. For the global transverse shear testing of laminated composite CFRP materials, R.C. Sanders, E.C. Edge, and P. Grant (British Aerospace PLC, Warton Division, Lancashire PR4 1AX, UK) reported on the basic failure mechanisms in laminated composites and the implication for aircraft design. Emphasis was given to the importance of the properties of the resin material employed in fiber reinforced laminates. This emphasis was supported by a cooperative investigation of the nonlinear viscoelastic response of resin matrix composites by C.C. Hiel and H.F. Brinson (VPISU) and A.H. Cardon

(Free University of Brussels, B-1050 Brussels, Belgium).

The vibrational, fatigue, impact, torsional, thermal cycling, buckling, and fracture mechanics properties of composite materials were described in about half of the 40 conference papers. G.J. Turvey (University of Lancaster, Bailrigg LA1 4YR, UK) compared the properties of steel, aluminum, CFRP, boron FRP, and glass FRP plate materials ring-stiffened with CFRP stiffeners. Vibration studies were reported for web-stiffened polyurethane foam sandwich panels (C.C. Chao, C.C. Wang, and C.Y. Chan, National Tsing Hua University, Hsinchu, Taiwan); tapered polar orthotropic circular plates (D.G. Gorman, Queen Mary College, London, UK); rectangular composite plates (M. Sathyamoorthy, Clarkson College of Technology, Potsdam, NY 13676); and thin laminates of bonded layers of carbon fibers (J.L. Wearing and C. Patterson, University of Sheffield S1 3JD, UK). An interesting paper on the tensile and flexural fatigue of balanced biaxial glass fiber laminates and of E- and R-glass fibers in filament-wound rings showed that the fatigue data could be appropriately normalized with the corresponding unidirectional strength properties (Mayer, Pearce, and Worthington, 1983). Unidirectional GFRP and CFRP were tested in tensile fatigue by P.T. Curtis and B.B. Moore (Royal Aircraft Establishment, Farnborough GU14 6TD, UK). Instrumented impact tests of notched CFRP materials involving thermosetting epoxy and polyimide plastics or thermoplastics such as polysulphone, polyethersulphone, polyetherimide, polyetheretherketone, and polycarbonate materials showed larger fracture energies for the thermoplastic laminates (A. Stori and E. Magnus, Central Institute for Industrial Research, Blindern, Norway).

J.-J. Barrau and S. Laroze (École Nationale Supérieure de l'Aéronautique et de l'Espace, 31055-Toulouse, France) and D. Gay (Institut National des Sciences Appliquées de Lyon [INSA], 31062-Toulouse, France) matched experimental measurements of the torsional behavior of an aluminum-epoxy cantilever beam with finite difference and boundary integral methods of calculating the stiffness and internal state of shear stress. The finite element method will be applied to the problem and experiments will be done with a helicopter rotor blade. S. Maksimović (Vazduhoplovnotehnički Institut, 11132-Žarkovo-Beograd, Yugoslavia) presented a finite element formulation for the nonlinear deformation of fibrous composite shell structures; and A. de Rouvray, E. Haug, and J. Dubois (Engineering System International SA, 94578-Rungis, France) gave a finite element simulation model for predicting the failure strengths of a variety of composite laminates with cut-out holes and notches. The project was supported by the French Ministry of Defense.

Efficient crack arrest with a buffer strip added to a unidirectional composite laminate with a strip spacing-to-width ratio of 4.0 was described by J.G. Goree (Clemson University, SC 29631); this was a joint effort with L.R. Dharani (University of Missouri, Rolla, MO 65401). Fracture of a bimaterial plate with a crack along the interface was described theoretically by E.E. Gdoutos (Democritus University of Thrace, Xanthi, Greece). A critical (J-integral) strain energy for fracture of about 51 kJ/m² was measured for a GFR epoxy resin composite with 5.0-cm fibers by B.D. Agarwal, P. Kumar, and B.S. Patro (Indian Institute of Technology, Kanpur 208 016, India); the work was supported by the Indian Aeronautics Research and Development Board. C.E. Harris and D.H. Morris (VPISU) showed enhanced x-ray photographs of cracking at the tips of precracked multiple layer [0/±45/90°] and [0/90°] graphite/epoxy laminate panels of different thickness-ess ranging between 8 and 96 plies.

The properties of composite engineering structures were the main subject of about one-third of the 40 conference papers. R.W. McLay, D.P. Tassie, and W.W. Thompson (General Electric Company, Burlington, VT 05402) described the development of a polyvinylchloride/vinyl ester/E-glass laminated sandwich turret structure for a 25-mm rapid-fire Gatling cannon for the US Navy. H. Becker, A.M. Dawson, P.G. Marston, and D.B. Montgomery (Plasma Fusion Center, Massachusetts Institute of Technology, Cambridge, MA 02139) reported their on-going study of mechanical property requirements for composite electrical insulator materials used for fusion magnets. Leading candidates are epoxy/glass and polyimide/glass composites because of their compatible thermal expansion properties to the metals employed.

Of course, aerospace engineering applications were a main concern of those attending the conference, as evidenced by support for the total range of research activities being provided by various national aerospace agencies. A number of attendees were from the Northern Ireland-based Learfan Company and were involved with the firm's new carbon fiber composite airplane. Armstrong and Strada (1983) have reported on the joint UK-Federal Republic of Germany (FRG) development of the carbon

fiber taileron for the Anglo-German-Italian Tornado aircraft. Other applications reported at the conference were tubular composites for spacecraft (R.D. Karam, Fairchild Space Company, Germantown, MD 20874), hybrid-filament-wound disks for energy-storing flywheels (M. Uemura, H. Iyama, and Y. Fukunaga, University of Tokyo, Meguro-ku, Tokyo 153, Japan), large FRP butterfly valves for cooling water circuits in power stations (M.H. Bryan-Brown and D.M. Walker, Central Electricity Generating Board, Bristol BS13 8AN, UK), and a computer-based study of reinforced automotive tire materials (H. Rothert and B. Nguyen, University of Hannover, D-3000, Hannover, FRG; and R. Gall, Hochschule der Bundeswehr Hamburg, D-2000 Hamburg, FRG).

Papers on construction and building dealt with the "pultrusion" of constant cross-section fiber reinforced profiles (T.F. Starr, Technolex, Somerset TA18 8BG, UK), and the design of temporary composite structures for use within the British Rail network (J.F. Kelly and J. Batchelor, British Rail, UK). There were two interesting papers on natural fiber composites. One discussed the suitability of fiber-cement composites for reinforced adobe structures in earthquake zones (D.G. Swift, Kenyatta University College, Nairobi, Kenya; and R.B.L. Smith and K.S. Rangasami, University of Nairobi, Kenya). The other dealt with the use of banana fabric-polyester resin composites for consumer articles (K.G. Satyanarayana, K. Subumaran, A.G. Kulkarni, S.G.K. Pillai, and P.K. Rohatgi, Council of Scientific and Industrial Research, Trivandrum 695 019, Kerala, India). ICCS/2 was closed with the announcement that ICCS/3 has been scheduled for 9 through 11 September 1985.

References

Armstrong, R.W., and J.A. Strada, "A German-British Development of a Carbon Fiber Composite Taileron for the Anglo-German-Italian Tornado Aircraft," Military Applications Summary Bulletin M125 (ONR, London, 1983).

Bunsell, A.R., and D. Valentin, *Damage Estimation in Carbon Fiber Reinforced Epoxy and its Influence on Residual Properties*, Final Report, USAFOSR 82-0141 (August, 1983).

Mayer, R.M., A. Pearce, and P.J. Worthington, "Some Aspects of the Fatigue Behavior of Fiber Reinforced Thermosetting Resins" (Sunbury, Middlesex TW16 7LN, UK: British Petroleum Research Center, September 1983).

11/28/83

OCEAN SCIENCES

ENVIRONMENTAL IMPACT OF WAVE-ENERGY CONVERTERS

by Robert Dolan. Dr. Dolan is the Liaison Scientist for Geology and Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the University of Virginia, where he is Professor of Environmental Sciences.

In *ESN* 38-1:36-38 (1984) I described progress in the development of a wave-energy project under way at Queen's University, Belfast. In that article I stressed the design and engineering of the Wells Turbine Unit, but said little about the environmental questions concerning the UK's wave energy program.

In the current issue of *Ocean Engineering* (Vol 10, No. 6, pp 459-469), P.K. Probert and R. Mitchell of the UK Nature Conservancy Council have summarized the environmental implications of the several wave-energy proposals under consideration by UK's Department of Energy. The following is a distillation of their article's abstract.

Wave-energy converters would have several effects on the hydraulic environment, most noticeably by modifying wave climate. A decrease in wave energy would influence shores and shallow subtidal areas, and would change the density and species of organisms they support. Fixed wave-energy converters would have more impacts than floating devices, mainly through their sheltering effect, the possibly stronger tidal flows generated between devices and shores, and the need to site fixed converters in the kelp zone.

Probert and Mitchell further state that the "devices would represent a new habitat for colonisation by attached algae and invertebrates and would probably attract fish, seabirds and seals. Seabed-mounted devices, once no longer operational, would become artificial reefs if left in place.

"Device noise might affect communication and navigation systems of fish and marine mammals. The navigational hazard to shipping posed by converters would be likely to increase the risk of severe oil pollution incidents in areas that are populated by internationally important numbers of seabirds.

"Other impacts would arise from the construction and maintenance of devices, an increased demand for building aggregate, the likelihood of intertidal flats being reclaimed, and conversion and

transmission of energy, and the general associated developments and industrialisation that would ensue."

They conclude that "although wave energy conversion harnesses a renewable source of energy it is not necessarily environmentally benign. Nevertheless, no environmental questions have been raised which would necessarily rule out further consideration of this energy source."

11/29/83

REMOTE SENSING IN BELGIUM

by G.R. Valenzuela. Dr. Valenzuela is a researcher in the Space Sensing Applications Branch, Naval Research Laboratory, Washington, DC.

The Laboratoire de Telecommunications et d'Hyperfrequences (LTH) at Université Catholique de Louvain, Louvain-la-Nueve, has a remote sensing program sponsored by the European Space Agency (ESA). In September 1983 the program was evaluated by an international panel of experts in the field: Dr. D.L. Croom (Rutherford and Appleton Laboratories, UK); Dr. D.S.W. Kwoh (TRW, US); and Dr. G.R. Valenzuela (Naval Research Laboratory, US).

The research at LTH is headed by Prof. A. Guissard and involves Dr. P. Sobieski, C. Baufays-Gaublomme, D. Vanhoenacker, and a scientist on inverse methods. A consultant on climate dynamics and oceanography helps in the work on ocean-surface modeling. LTH is directed by Prof. A. Vander Vorst, and the remote sensing program is managed for ESA by G. Brussaard of the European Space Research Centre (ESTEC) at Noordwijk, The Netherlands.

The short-term objective of the LTH program is to perform unified assessment of microwave sensors at 2 to 70 GHz for monitoring the ocean surface from spacecraft. (Frequencies up to 300 GHz are of interest for the longer term.) This program goes beyond the European Remote Sensing Satellite--ERS-1--and envisions the use of one comprehensive and accurate model for the ocean surface, in combination with electromagnetic (EM) scattering theory, to predict the performance of various sensors to be deployed (e.g., radiometer, scatterometer, altimeter). The program also deals with payload simulation on board satellites to optimize the sensor package.

Thus far the work at LTH has consisted of a critical assessment of: (1) the present knowledge about hydrodynamics and modeling of the sea surface (C. Baufays-Gaublomme), (2) the influence of sea foam on microwave measurements (D. Vanhoenacker), and (3) theories for EM scattering from rough surfaces, with emphasis on the ocean (A. Guissard). Inverse methods are also being considered.

The emphasis in the ocean surface modeling has been on a review of surface wave kinematics and dynamics (generation, dissipation, and modulation of short waves by long waves), and their statistical description and characterization by a wave spectrum. The evaluation panel recommended that future attention should be given to the development of the wave spectrum by wind, energy transfer by resonant nonlinear interactions, and dissipation by viscosity and wavebreaking. Moreover, in the interaction of short waves with long waves it is important for scattering theories to include the residual correlation introduced by the dominant waves--in addition to the fast decorrelation of the short Bragg-resonant waves. The panel also noted that in general it is not possible to infer wave-number spectra from point measurements, since for wind-waves and advection by orbital velocity of dominant waves there is no one-to-one relationship between frequency spectrum and wave-number spectrum.

Another major effort at LTH has been to develop a unified approach to predict the response of active and passive sensors. Available results from the US National Aeronautics and Space Administration's Sea Satellite (SEASAT), field experiments, and laboratory studies have been examined to correlate these sensors. However, the review has not been successful. So the LTH work has concentrated on the influence of foam and whitecaps on microwave measurements to assess whether these might cause discrepancies. Studies and models are available for the characterization of foam and whitecaps to predict the response of radiometers (e.g., Stogryn, Williams, Droppelman, Tang, Rosenkranz and Staelin); see Pandey and Kakar (1982) for a recent effort. Seemingly, these models still are not realistic enough to predict in a unified manner the response of passive and active sensors for frequencies between 1 and 37 GHz. The recommendation of the panel was for the development of a more realistic model for the air-turbulent mixed layer-sea interface for the different environmental and radar

parameters. With this objective in mind, the panel recalled the laboratory measurements on spray above water for wind by Lai and Shemdin (1974); a review of the unified scattering model of Wu and Fung (1972) also was suggested.

Guissard performed an excellent critical review of available scattering theories for rough surfaces. In particular he reviewed the John W. Wright composite surface (two-scale) scattering model and the pertinent contributions by Valenzuela, Barrick and Peake, and others (e.g., see Valenzuela, 1978). There have also been other contributions; Brown (1978), using Burrows' method, was able to combine specular scattering, Bragg scattering, and shadowing in one formulation. Bahar also has been developing a "full-wave" approach for scattering from rough surfaces since the early seventies and recently applied it to a two-dimensional random surface (Bahar, 1981). In the full-wave solution the EM boundary-value problem is posed in terms of equivalent generalized telegraphists equations--an approach which allows one in a formal manner to include lateral waves, surface waves, and radiation fields. Then the coupling coefficients are obtained from the boundary conditions applied to the differential equations describing the model fields. However, explicit results are only possible by iteration (terms up to second order are kept) and steepest descent integration. The validation of the full-wave approach is based on the agreement of results with previous work for the limit cases of a gentle undulating surface (physical optics) and for a slightly rough surface (Bragg scattering). However, no detailed analysis of the accuracy of the general results is available. Recently the full-wave approach has been applied to a two-scale surface (Bahar and Barrick, 1983). Future efforts to improve scattering theories probably should concentrate on the more exact Integral and Green's Function Methods. In any case, for any advancement in scattering theory a realistic hydrodynamic description of the ocean surface is essential.

In regard to the backscatter of microwaves from water surfaces, there is new evidence that specular scatter might be more important than previously thought (Kwoh and Lake, 1981). This is not too surprising since Wright and coworkers identified three scattering mechanisms in a wind-wave tank (Duncan et al., 1974; Keller et al., 1974). Accordingly, the amount of specular scattering in the backscatter of microwaves from the ocean surface should be quantified for the various radar and environmental parameters. However, the experience at the US Naval Research Laboratory has been that for radar frequencies less than 10 GHz and angles of incidence between 15 and 80 degrees from nadir, at least 80 to 90 percent of the contribution to the radar return is due to Bragg scattering (Plant and Schuler, 1980). Of course, this statement applies for relatively large illumination areas on the ocean; at higher resolution and focused operation one would tend to discriminate against Bragg scattering, and then specular scattering might become more important.

Overall, the evaluation panel was highly impressed by the quality of the initial effort in the remote sensing program. Because of the LTH group's high scientific competence, some important contributions in the field of remote sensing should be forthcoming in the near future.

References

Bahar, E., *Radio Science*, 16 (1981), 331-341.

Bahar, E., and D.E. Barrick, *Radio Science*, 18 (1983), 129-137.

Brown, G.S., *IEEE Transactions*, AP-26 (1978), 472-482.

Duncan, J.R., W.C. Keller, and J.W. Wright, *Radio Science*, 9 (1974), 809-819.

Keller, W.C., T.R. Larson, and J.W. Wright, *Radio Science*, 9 (1974), 1091-1100.

Kwoh, D.S.W., and B.M. Lake, *IUCRM Symposium on Wave Dynamics and Radio Probing of the Ocean Surface* (Miami Beach, FL, 13-20 May 1981).

Lai, R.J., and O.H. Shemdin, *Journal of Geophysical Research*, 79 (1974), 3055-3063.

Pandey, P.C., and R.K. Kakar, *IEEE Transactions*, OE-7 (1982), 135-139.

Plant, W.J., and D.L. Schuler, *Radio Science*, 15 (1980), 605-615.

Valenzuela, G.R., *Boundary-Layer Meteorology*, 13 (1978), 61-85.

Wu, S.T., and A.K. Fung, *Journal of Geophysical Research*, 77 (1972), 5917-5929.

11/4/83

PHYSICS

NEW FLEXIBILITY FOR PLASMA RADIATION SOURCES

by David Mosher. Dr. Mosher is the Liaison Scientist for Physics in Europe

and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until July 1984 from the Naval Research Laboratory, where he is Supervisory Research Physicist.

In recent years, intense sources of soft x-radiation have been produced in many laboratories by the electrically driven implosion of annular plasmas. In the US and France, multi-megampere transmission-line generators are used to implode high-atomic-number gases to create sources for x-ray vulnerability testing of defense systems to exoatmospheric nuclear bursts (Stallings et al., 1979). On a smaller scale, modest pulsed-power systems and capacitor banks (Shiloh et al., 1978), produce similar z-pinch plasma sources for spectroscopy, materials science studies, high resolution lithography of large-scale integrated circuits, and x-ray laser investigations. Recently, a group at Imperial College (London) has proposed a layered z-pinch implosion to investigate the resonant pumping of a lasing transition in Ne IX using 11-angstrom line emission from Na X (*ESN* 37-9:373 [1983]).

For all these investigations, a cylindrical annulus of gas is injected through a pulsed supersonic nozzle into a few-centimeter vacuum gap separating two high-voltage electrodes. When the voltage pulse is applied across the electrodes, the gas ionizes, and a high current flows along the annulus. The current produces magnetic forces which implode the annulus to small radius. At peak compression, the energy from the radial acceleration has been converted to thermal energy, and radiation is emitted by the heated plasma. The spectrum of ultraviolet and x-radiation emitted depends on the type of gas used, its density, and the temperature achieved in the compressed plasma. Researchers can modify the radiation spectrum by varying these parameters. They can choose gases which have characteristic lines at wavelengths of interest, they can soften the spectrum and increase the continuum component by operating at high density and high atomic number, or they can enhance line emission and harden the spectrum by operating at low density.

The range of operating spectra attainable with a gas-puff plasma radiator is limited by the requirement to match the dynamics of the plasma load to the electrical generator driving the implosion. In order to transfer electrical energy to the plasma efficiently, the plasma must reach peak compression at a time just after peak discharge current. For a capacitive electrical system, this matching condition is achieved when the ringing frequency, Ω, of the electrical system satisfies

$$\Omega^2 = 10^{-2} I_o^2 / 2mR_o^2, \qquad (1)$$

where I_o is the short circuit current, R_o is the initial radius of the gas-puff annulus, m is the plasma mass per unit length, and cgs units are employed (*ESN* 37-9:375 [1983]). The electrical generator fixes Ω and I_o, and the supersonic nozzle hardware fixes R_o. The researcher can vary m about the value determined by equation (1) by adjusting the gas pressure behind the pulsed valve in order to control the final density and temperature. However, variations of m by more than a factor of three lead to significantly reduced energy coupling to the plasma.

Thus, the need to match the implosion to the generator limits the range of achievable densities and temperatures for any chosen gas. These parameters are coupled: lower density means higher temperature, and vice versa. Also, the implosion dynamic produces specific radial profiles (usually nonuniform) of density and temperature at peak compression.

For vulnerability testing, lithography, and some materials research, density and temperature limitations may not present serious problems. In other applications, the limits can cause difficulties. For spectroscopic studies, the effects of nonuniformities must be unfolded by complex inversion procedures to obtain line shapes. Also, cool or dense plasma regions can produce undesirable absorption features in the line spectrum. These effects are particularly disturbing for certain line-shape studies where optically thin profiles are desired. Densities high enough to produce sufficient radiation tend to have significant line reabsorbtion. For x-ray laser studies, it may not be possible to simultaneously achieve the required plasma parameters for pumping, inversion, and emission.

Researchers at the Ruhr-Universität (Bochum, Federal Republic of Germany [FRG]) have developed a variation on the gas puff, the gas-liner pinch, which provides a means of overcoming these limitations. The extra flexibility is provided by adding a second and independently controllable narrow column of gas on the axis of symmetry of the annulus. The major advantages of the device are the possibility of controlling the temperature and density of specific

constituents to a much higher degree than in a single-component gas puff, and the ability to obtain plasmas in which these parameters are uniform over the emitting region. These qualities are required for the program objectives: to study line broadening in dense plasmas, to develop a source for resonance fluorescence research, and to investigate high temperature x-ray spectroscopy for fusion studies.

I spoke with K. Finken (now at the nuclear research center in Jülich) and U. Ackerman of the Institute for Experimental Physics V about the gas-liner pinch. The institute, led by H.J. Kunze and B. Kronast, houses a variety of projects involving dense plasma pinches for spectroscopy and for the investigation of laser-plasma interactions of interest to inertial confinement fusion. The institute is one of four at Bochum studying many types of plasmas. The university's overall plasma-physics effort is one of the most comprehensive in Europe and, judging by the extensive publication record, one of the most prolific. Research at the Institute for Experimental Physics II, under H. Schluter and F. Wiesemann, concentrates on plasma wave and heating phenomena important to magnetic confinement fusion. The Institute for Theoretical Physics IV, directed by K. Schindler, is well known for contributions to astrophysical plasma physics. Theoretical Physics I concentrates on nonlinear wave phenomena--the works of P.K. Shukla and M.Y. Yu on plasma solitons and nonlinear waves are prominent.

The gas-liner pinch apparatus is shown in Figure 1. The outer gas annulus, called the driver gas, has a radius of 8 cm and can be mass optimized for good energy coupling to the electrical circuit. For high-temperature plasmas (100 eV to 1 keV), a low density of high atomic number gas is employed as the driver; for low temperatures (down to several electronvolts), a high density of hydrogen or other light gas is employed. The second gas stream, injected in a narrow beam along the axis, is called the test gas since its atomic species determines the characteristics of the radiation once the driver collapses onto it.

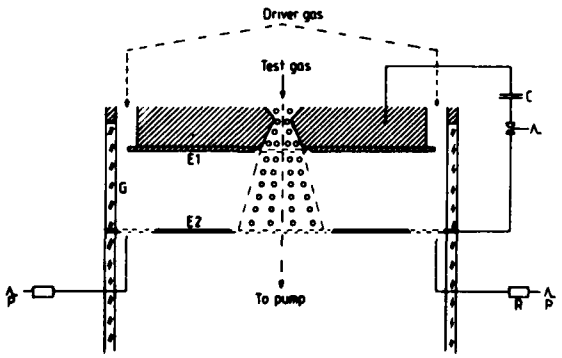


Figure 1. Schematic design of the gas liner pinch.

A homogeneous test plasma requires a large pinch-aspect ratio--the radius of the outer shell must be larger than the plasma length defined by the distance between electrodes. The interelectrode distance can be varied between 0 and 5 cm, with 2 cm typically used for spectroscopic measurements. A homogeneous test plasma also requires that it have a much smaller particle number than the driver. Under these conditions, the test plasma temperature and the total electron density available to excite radiation will be determined by the driver's properties, which can be varied independently of the test gas density. The test gas density can remain low to produce optically thin radiation while the high electron density of the driver produces strong emission. Also, since the test gas does not take part in the implosion and has no large macroscopic velocity, emitted lines do not exhibit a Doppler shift or broadening. Observed broadening can therefore be attributed unambiguously to mechanisms under study, such as the Stark effect. By collimating the test gas in a narrow stream, the emitted radiation can be limited to a uniform central portion of the collapsed plasma, thereby eliminating complications produced by temperature and density gradients.

As is well known to z-pinch researchers, the initial uniformity of the discharge determines the quality of the compressed plasma column. Uniform preionization of the annulus is achieved in the Bochum experiment by 50 resistively decoupled discharge pins arranged in a circle just under the lower electrode. A portion of the electrode is a stainless steel mesh which allows the ionizing vacuum ultraviolet radiation and electrons to enter the interelectrode space and provides a means of pumping the gas pulsed through the upper electrode. The pin arrangement alone provides a reproducible discharge only if the interelectrode distance is under 2 cm. The distance can be increased to 5 cm with good results only if the glass wall shown in Figure 1 is employed along with the pins. The wall defines a desirable, sharp outer boundary for the plasma annulus and establishes the initial breakdown path.

Careful timing of the two pulsed valves with respect to the electrical pulse is vital for proper operation of the gas-liner pinch. The distribution of annular gas density with time following release by the fast valve was recorded with an ionization gauge (Finken and Ackermann, 1983). Absolute density calibration of the gauge to within a factor of two was obtained by measuring the pressure and gauge current during static filling of the chamber with gas. The data were used to determine optimal timing of the two valves relative to the electrical pulse: the driver gas is injected early enough to form a reproducible flow pattern, while the test gas is injected as late as possible to avoid radial expansion. In experiments with a hydrogen driver, the delay between the two valves was about 1.0 ms, and the delay between the test gas trigger and the electrical discharge was about 1.9 ms. The optimum time delay between preionization and the main discharge is 2 to 10 μs.

The present device has an electrical energy storage of 1.2 kJ at a 20-kV charge of 6-μf capacity and a ringing frequency of 2.5 μs. Currently, Stark broadening of multiply charged light ions is under investigation. These studies require electron densities in the 10^{18} cm^{-3} regime and 10-eV temperatures. A hydrogen driver with fill pressures of 0.1 to 0.3 Torr provides the correct conditions. These electrical and driver parameters have been used in a simple model for the annular implosion, and good agreement between the calculated and observed implosion time is found for a compressed plasma density of 5×10^{17} cm^{-3}. The time of peak compression was determined from the maximum emission of continuum radiation. More precise measurements of the electron density distribution versus time were provided by interferometery; researchers used a double holographic exposure technique with a frequency doubled Nd-YAG laser of 5-ns duration. At all times, interferometry showed the plasma had good cylindrical symmetry so that an Abel inversion could be used to infer the radial density distribution. Results of this procedure are shown in Figure 2 for maximum compression. The average value agrees well with the implosion calculations. One important result for spectral measurements was that addition of test gas changed neither the density maximum nor its spatial distribution.

The electron temperature of the column at peak compression was determined by using a test gas containing

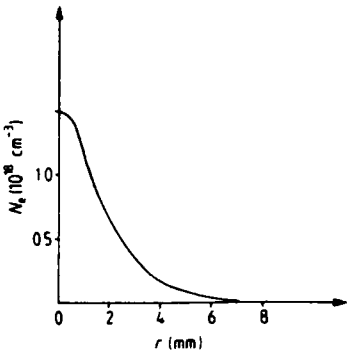


Figure 2. Radial electron density distribution.

carbon and measuring the ratio of the C III, 2297-angstrom line to the C IV, 2530-angstrom line. Electron temperatures of 11 eV were measured with a 5-cm-long column and 7 eV for one of 2-cm length. The lower value is associated with heat conduction to the electrodes with the shorter length. Lengths over 5 cm also display lower temperature because the high impedance of the discharge depresses the current.

He II Stark broadening measurements have been used to determine the change in density with plasma length. The variation in temperature inferred from these measurements in conjunction with pressure balance calculations agrees with the carbon line measurements. The He test gas studies also demonstrated an important advantage of the gas liner pinch. The radial distribution of He II light was limited to the central flat-topped portion of the electron density distribution, indicating the uniform plasma environment desired for spectroscopy.

Fusion studies will require kiloelectronvolt temperatures for x-ray spectroscopy of the test plasma. To achieve this condition, a higher power facility is being constructed at Bochum. The new gas-liner pinch will have 12-μf capacitance charged to 60 kV for a stored energy 15 times greater than the existing device. Finken believes the system will be able to accelerate the driver to about 2×10^7 cm/s, so that argon ions will each have about 10-keV kinetic energy. Thermalization will lead to plasma temperatures in the 100-eV to 1-keV range, comparable to those of larger puff gas systems in Europe and the US. The gas-liner pinch may prove superior to these other systems not only for spectroscopy but also for x-ray laser studies. The extra

flexibility in choosing plasma parameters, the uniform emission region, and the ease of introducing two components are attractive features for a resonantly pumped laser operating in the x-ray regime.

References

Finken, K.H., and V. Ackermann, *Journal of Physics D: Applied Physics*, 16 (1983), 773.

Shiloh, J., A. Fisher, and N. Rostocker, *Physical Review Letters*, 40 (1978), 515.

Stallings, C., et al., *Applied Physics Letters*, 35 (1979), 524.

11/30/83

NOISE AND VIBRATION ABATEMENT BY ACTIVE METHODS

by Chester McKinney Dr. McKinney is the Liaison Scientist for Underwater Acoustics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from The University of Texas at Austin, where he is Senior Research Scientist at Applied Research Laboratories.

A subjective definition of airborne noise is "any disagreeable sound." It might be difficult to reach a consensus about whether some music and a great deal of speech fit the definition--but not so with virtually all industrially generated sounds. The effects of such noise range from community annoyance to hearing damage for people who must work in particularly noisy places.

In recent decades recognition and knowledge of these effects have increased steadily, and in parallel there has developed a large body of knowledge about how noise can be attenuated. Following conventional wisdom, one first aims to eliminate the generation of industrial noise by using good design techniques, such as low-noise fan blades and highly balanced motors and engines. But because of technical and economic limitations, the residual sound radiation (generally from turbulent air, vibrating mechanical parts, or chemical explosions) often is above acceptable thresholds. In most cases the total acoustic energy involved is very small--on the order of watts or at most hundreds of watts.

The conventional approach for noise abatement is to passively absorb the sound energy (i.e., convert it into heat via viscous flow) since such an action will have negligible impact on the ambient temperature. The technology for passive attenuation is well developed and is employed extensively in mufflers (large and small), absorptive wall panels, and damping coatings for vibrating structures. The absorption efficiency for a given passive device generally increases with the frequency of the noise; and for frequencies above about 100 Hz, passive absorption is the usual solution. For very low frequencies the attenuators become very large and costly. Enter active noise reduction.

Background

It has long been known that one wave can be canceled by another wave of identical amplitude and opposite phase if they are combined at the same point in space (destructive interference). In 1933, Paul Lueg applied this concept to attenuating a noise wave by combining with it a specially generated opposite phase wave. Lueg was granted a US patent in 1935 (US Patent 2,043,416, "Process of Silencing Sound Oscillations," originally filed in Germany, 27 January 1933). There is no evidence that the technique was exploited at that time. In the early fifties Harry Olsen and coworkers at RCA initiated a program on active reduction of noise and vibration and developed several laboratory demonstrations, including noise reduction in the small volume occupied by the head of the operator of a noisy machine (Olsen, 1956; Olsen and May, 1953). Conover conducted experiments on canceling the noise from an open-air transformer bank but found that while the sound level could be reduced significantly in some directions, it was enhanced in others--that is, the noise was redistributed, not absorbed (Conover, 1956). Evidently interest in active noise reduction was slight for the next decade until Jessel et al. published work on active noise reduction in ducts (Jessel, 1968; Jessel and Mangiante, 1972). This was followed by more duct work by Swinbanks (1973), Poole and Leventhall (1976), and others.

Within the past 5 years a host of papers from a number of groups has appeared. Interest in active noise reduction has reached a new peak if the number of meetings on the subject during the past 6 months is any criterion. There were 20 papers at INTERNOISE '83 (*ESN* 37-10/11:426-428 [1983]), a special session at the 11th International

Congress on Acoustics (*ESN* 37-12:483-485 [1983]), a special session of five invited papers at the Acoustical Society of America meeting in November 1983, and a 1-day seminar and exhibition (in London on 2 November 1983) sponsored by the Institution of Mechanical Engineers and the Institute of Acoustics.

Most of the effort to date has dealt with noise reduction either inside ducts or at the open ends of ducts, with much less effort on large volumes, open areas, or large distributed noise sources. The reasons are that noise in pipes (e.g., air conditioning ducts, exhaust and intake pipes, and gas pumping systems) is important, and that this is perhaps the least difficult case to attack first. It should be emphasized that active techniques are considered to be of primary interest for low frequencies only and should complement the use of passive devices for mid and high frequencies.

The fact that active noise abatement remains a novelty is evidence that using one sound wave to cancel another, while simple in principle, is difficult in practice when the wave to be canceled is three dimensional, with a complex frequency spectrum. To appreciate the difficulty and to introduce some of the recent developments, it may be instructive to consider a few evolutionary developments.

Active Noise Reduction Techniques

Consider some type of noise source, a blower fan for example, at one end of a duct, with the noise propagating from left to right. If the noise were strictly repetitive and unvarying, the canceling source could be placed very close to the noise source, to also radiate down the duct. In this case the new source would be programmed to radiate a mirror image (opposite phase) wave. In fact the two sources would alternately pump energy into the other and be absorbed. This is equivalent to stating that the two sound sources are driving reactive loads, with no radiation. In this case the canceling sound source is acting as an absorber. In general, the situation just described is difficult to achieve because most noise waves are constantly changing in amplitude and phase. One does not have *a priori* knowledge about the wave to be canceled.

A more common arrangement is to sample the noise field near the source with a microphone, the output of which--with suitable spectrum shaping, phase inversion, time delay, and amplification--drives a loudspeaker mounted downstream in the wall of the duct. With an ideal system, the downstream noise is canceled, but the injected signal also propagates to the left (upstream) toward the noise source, resulting in a standing wave field. In this case the canceling system acts like a reflector to redistribute the noise energy. The important point is that the upstream moving wave is also sensed by the microphone. We have a closed-loop feedback system which may well be unstable or at best restricted in allowable gain. While this type of system can provide attenuation, it is limited by the undesirable upstream wave.

Jessel sought to overcome this defect by using an array of three loudspeakers to form a dipole and monopole to yield a cardioid pattern with maximum propagation downstream and minimum upstream. Swinbanks used two speakers spaced along the length of the duct with the first having more delay than the second. For certain frequencies and spacing the two upstream signals cancel. Another solution, known as the Chelsea monopole (Hong, 1982), adds an electrical feedback of the signal driving the loudspeaker, with appropriate delay and phase inversion, to the sensor microphone to cancel the loudspeaker wave arriving at the microphone but not the noise signal. If the sensor microphone is moved along the duct to approximately the same distance from the noise source as the loudspeaker, the two delay devices can be eliminated, to leave only a microphone, inverting amplifier, and loudspeaker. This is known as the tight-coupled monopole. The system can be expanded to add a second tight-coupled monopole system downstream, which cancels the residual noise propagating beyond the first monopole. These monopoles are independent, and presumably the cascading could continue. All of these schemes are aimed at reducing the upstream radiated wave of the canceling sound source; and all work, some better than others, to attenuate noise by 10 to 20 dB or more, depending on frequency and the particular arrangement. There is a considerable range in complexity of electronics, but the major cost and probably the weakest link is the loudspeaker. Also, these techniques are useful for providing attenuation in ducts but are not generally applicable to other situations.

A different approach has been taken by Chaplin and coworkers at Essex University to cancel repetitive noise only (Chaplin, 1980). A signal synthesizer is synchronized with the noise source (e.g., speed of an engine) and

drives an amplifier and loudspeaker. The synthesizer is programmed to use a special algorithm to develop a canceling signal. A monitor microphone, mounted in the noise field, provides a primitive type of feedback to the synthesizer. For one type of algorithm, at the start of a cycle the synthesizer generates, for a selected portion of the cycle, a signal of a given polarity. The monitor tells the synthesizer whether the noise level increased or decreased. If it decreased, on the next cycle the signal, in the same time segment, is increased, and this is repeated until no more noise reduction is measured. If the first signal increased the noise level, the synthesizer tries the reverse polarity. After dealing with the first time segment of the cycle, the synthesizer moves to the next until the end of the cycle. Then it continues to update the synthesized signal with each cycle of the noise source. The Essex technique depends on the fact that periodic noise does not change much from cycle to cycle. Changes in speed are accommodated by the synchronization. The cancellation device develops its own signal for maximum cancellation of the noise at the point of the monitoring microphone. Other algorithms depend on starting with a known measured spectrum plot and optimizing from that point, resulting in a saving of time in signal synthesis. It should be noted that the Essex technique cancels only the periodic components and not other noise or signals, a feature which can be used to advantage for some applications.

The reduction of unwanted mechanical vibration of walls, floors, and machinery is closely related to noise abatement. Such vibrations, if excessive, can damage machines and can annoy or harm people. Mechanical vibrations also are a major source for generating air- and water-borne noise. Common passive techniques for vibration reduction include tuned filters (mass-spring combinations), friction couplers, and damping panels and coatings. One form of active attenuation is to couple the vibrating body to another out-of-phase vibrating mass.

The Essex technique for sound reduction can also be applied to vibration reduction by using electromechanical force actuators to support machinery-mounting pads. The actuator motion is synchronized with the machinery vibration and moves in phase with the vibration. For example, when the machinery-mounting pad moves downward, the actuator moves down also to give, in effect, a very soft spring. For nonsynchronized motion the actuator is very stiff. An accelerometer sensor, mounted on the floor, feeds back signals to the signal synthesizer, which develops the signal to drive the actuator. The procedure for signal synthesis is basically the same as that for noise reduction. It is important to note that with the Essex method, the actuators must support the entire weight of the vibrating machine and its pad. In experiments using available actuators to isolate the vibration of small unbalanced motors, the vibration reduction (by 40 dB) has been impressive. However, for the technique to achieve commercial success, it will be necessary to develop actuators that are suitable for use with heavy loads and that can be produced at acceptable costs. The Essex group is confident that suitable units can be designed but has not provided any details.

The London Seminar on Active Noise and Vibration Control

Does recent interest in active noise control indicate that the approach has finally arrived and is now poised to have an impact on operational noise abatement (as opposed to laboratory demonstrations)? In search of an answer I attended the London seminar, a meeting aimed at identifying the practical applications of active noise abatement.

The seminar and exhibition attracted more than 200 people, the majority being from industries which have noise and vibration problems. There were two excellent overview papers: one by H.G. Leventhall (Atkins Research and Development and Chelsea College, UK) and one by M.A. Swinbanks (MAS Research, UK). These speakers reviewed some interesting history, described recent developments, and presented data from a variety of demonstration projects and industrial applications. Swinbanks gave an excellent historical review of active vibration control, noting that such techniques were used in the last century and are commonplace today. He stressed that industry is willing to build and use quite massive and expensive devices, both passive and active, to minimize vibration. The phase opposition oscillating (or rotating) mass is suitable for use where the unwanted vibration is periodic. A good feature is that such devices are not required to support the weight of the vibrating body.

A forum of four speakers gave short talks on diverse and relevant aspects of the subject. Prof. E.J. Richards (Institute of Sound and Vibration Research [ISVR], University of Southampton, UK) reviewed some of the fundamental research done at ISVR on understanding the

nature of noise and vibration generation, particularly by impact types of machines. He discussed some of the progress made on noise reduction and problems which remain to be solved. A.T. Fry (Sound Attenuators Ltd., UK) gave some views of a hardware supplier, one who must provide a reliable service and produce a profit. After reviewing a large number of possible applications for active control, he concluded that the best areas to deal with were random noise in ducts, gas turbine intake and exhaust, diesel engine exhaust, compressor inlet noise, and repetitive noise control with headphones. He elected not to include enclosure noise control, large source noise control, source modulation, and vibration control. The two lists of items are probably good indicators of what can be handled in the near future and what will require extensive additional research and development. D.R. Easson (National Research and Development Corporation, a UK government organization) reviewed the several demonstration projects which his organization has sponsored in the past. He commented that despite the progress made to date there is no visible active-sound-control industry and wondered why this is the situation. R.A.T. Iredale (Central Electricity Generating Board, UK) gave at least a partial answer when he discussed the design of large electric power plants. He stressed the importance of including adequate noise control in the initial design rather than being forced to cure problems later. Design engineers are conservative by nature and prefer to use methods which have been well proven and which have inherent low failure rates. He felt that these designers are not comfortable with the reliability of present systems. The scheduled talks were followed by a session in which a panel of experts fielded questions from the audience. The discussion was lively, and in general there appeared to be enthusiasm for active noise and vibration reduction.

The exhibition of active attenuation devices and methods was well done and well received by the seminar participants. Eight groups had booths, some with as many as four demonstrations each. University research was well represented by Essex University (Wolfson Centre), ISVR (Wolfson Centre), Chelsea College (University of London), and Heriot Watt University (Scotland). Topexpress Ltd. (closely associated with Cambridge University) had three demonstrations. Other companies present included Plessey Marine Research Ltd., Cullum Detuners Ltd., MAS Research Ltd., and Moniton Technic Ltd. (closely associated with Chelsea College). All of the companies are involved with active noise attenuation, but the flavor is definitely R&D at this time--not production.

Several exhibits related to in-duct noise reduction and several to attenuation at the outlets of exhaust stacks. The Heriot Watt exhibit contained data from experiments to reduce diesel truck and motorcycle exhaust noise with loudspeakers attached to the tailpipes. Essex University had an interesting demonstration of selective periodic noise cancellation in a special headset. The signal synthesizer develops a waveform to cancel the periodic components of noise which, after amplifications, is used to drive small headphone speakers. Other signals, such as voice, are not affected significantly and can still be heard by the listener. This appears to be a specialized but effective use of active noise attenuation. Essex University, Topexpress, and Plessey Research all had demonstrations of active vibration control using force transducers (described earlier as the Essex method) as opposed to inertial methods. ISVR demonstrated the damping of plate vibration due to sharp impacts by using a synchronized opposing force.

Concluding Remarks

It is evident that a number of new techniques have been developed in the past few years; some of the major problems have been at least partially solved; some impressive demonstrations have been conducted; several noise-abatement hardware companies have serious programs under way; and industries with noise problems appear to have increasing interest. Significant low-frequency active noise attenuation (by 10 to 20 dB or more) can be achieved in ducts, at exhaust outlets, and in similar situations using existing components. Active techniques may prove to be most appealing for application to moving noise sources (e.g., diesel trucks, motorcycles, ships, and submarines) where space is very limited. Solutions to the noise problems of large distributed noise sources in open space or in rooms are much more elusive. Active control of vibration is feasible for some machines but not for others, and for some techniques critical components have yet to be devised. All of the above seem to indicate that the time is ripe for active noise abatement to move into the marketplace in a selective way within the next 5 years. It is obvious that serious problems remain, but at the moment there is a sizeable

R&D community in universities and industry to carry on such work. However, support for these groups is apt to diminish unless some of the proven techniques find commercial acceptance in the near future.

Applications discussed in this article relate primarily to civil uses, but they have naval applications as well. Navies go to extremes to reduce internal vibration in submarines--which may result ultimately in hull vibrations and the consequent radiation of sound. The comparatively small size of active components is appealing for this application.

References

Chaplin, G.B., "The Cancellation of Repetitive Noise," in *Proceedings of the 1980 International Conference on Noise Control Engineering*, ed. G.C. Maling (New York: Noise Control Foundation, 1980), 699-702.

Conover, "Fighting Noise With Noise," *Noise Control* (1956), 78-82.

Hong, W.K.W., K. Eghtesadi, and H.G. Leventhall, "The Tandem Tight-Coupled Active Noise Attentuation in a Duct," *Acoustic Letters*, Vol 6, No. 2 (1982), 19-24.

Jessel, M., "Sur les Absorbers Actifi," in *Proceedings of the 6th International Congress on Acoustics* (1968).

Jessel, M., and G. Mangiante, "Active Sound Absorbers in an Air Duct," *Journal of Sound and Vibration*, 23 (1972), 383-390.

Olsen, H.F., "Electronics Control of Noise, Vibration, and Reverberation," *Journal of the Acoustical Society of America*, 28 (1956), 966-972.

Olsen, H.F., and M.E. May, "Electronic Sound Absorber," *Journal of the Acoustical Society of America*, 25 (1953), 1130-1136.

Poole, J.H.B., and H.G. Leventhall, "An Experimental Study of Swinbanks' Method of Active Attenuation of Sound in Ducts," *Journal of Sound and Vibration*, Vol 49, No. 2 (1976) 257-266.

Swinbanks, M.A., "The Active Control of Sound Propagation in Long Ducts," *Journal of Sound and Vibration*, 27 (1973), 411-436.

11/18/83

X-RAY LASER RESEARCH REPORTED AT ECLIM

by David Mosher.

Researchers from around the world recently assembled at Imperial College, London, to discuss the interaction of high-power laser radiation with matter. Held from 25 through 30 September 1983, the 16th European Conference on Laser Interactions with Matter (ECLIM) focused on laser-driven inertial confinement fusion (ICF). Most of the presentations dealt with the interaction of tightly focused laser beams with planar ablation plasmas or spherical ICF targets, the dynamics and stability of such plasmas, the coupling of laser energy to them, and the diagnosis of the beam-plasma interaction.

For the high energy-density conditions of fusion-target plasmas, diagnosis of emitted or transmitted soft x-radiation is especially important to an understanding of plasma heating and subsequent motion, and to the compression of the target core containing the fusion fuel. However, a few of the talks dealt with x-ray production and the underlying processes not as ICF diagnostic tools but as means to create soft x-ray lasers. Presentations related to the x-ray laser are described here.

Background

A laser operating in the x-ray regime would provide a means to profoundly increase our knowledge of molecular structure and chemistry. The wave coherence of the laser beam would make possible the construction of x-ray holograms recording the three-dimensional structure of atoms in molecules. Diffraction patterns produced by incoherent x-ray sources (such as synchrotron radiation from a storage ring) provide two-dimensional information that must be unfolded by computer in conjunction with guesses about the three-dimensional structure. The difficulties and ambiguities associated with diffraction analyses of complex structures such as DNA could be eliminated by viewing x-ray holograms through a microscope to obtain a magnified, three-dimensional image of the molecule. X-ray energies are needed in order to view the atomic scale because resolution is limited by the wavelength of the illuminating radiation. X-radiation also penetrates metals more deeply than longer wavelength radiations and therefore has potential advantages in a number of defense applications.

There are several reasons why a coherent x-ray source is difficult to create. The lasing transition must be a high-energy excited state so that its decay produces x-ray photons. As the spontaneous decay of such states may be as short as 10^{-15} s, rapid pumping is

needed for the required population inversion. Unlike visible and near-visible radiation, x-rays cannot be simply reflected at the boundaries of the lasing medium. Because the beam must then be developed in a single pass of the radiation through the medium, a high density of lasing atoms is required. These facts of nature conspire to require a very high incident power density to pump the population inversion. Currently, researchers are experimenting with laser or pulsed-power driven transitions about 10 times less energetic and longer in wavelength than desired for applications. Free electron lasers can theoretically operate in the x-ray regime, but technological problems associated with the required high beam quality and small wiggler dimensions currently limit their operation to the visible or longer wavelength range (*ESN* 37-10/11:419 [1983]).

Recombination Lasers

Recombination of ions in a rapidly expanding and cooling laser-produced plasma has been a favorite mechanism for generating the population inversion required for soft x-ray lasing. As highly stripped ions recombine upon cooling, the free electrons initially condense into excited states. When a lower state has a fast radiative decay, the upper state can achieve a higher population, and lasing between the two becomes possible. During the last few years, a group led by Dr. Geoff Pert and coworkers at Hull University (UK) has investigated this mechanism on the 182-angstrom Balmer-alpha transition of hydrogenic carbon. In the original experiment, carbon fibers were irradiated with a Nd-glass laser producing a pulse of up to 10 J at 1.06-μm wavelength in about 200 ps (Jacoby et al., 1982). In gain measurements, a single cylindrical concave lens and spherical convex lens system produced a line focus 2-mm long by 40-μm wide on the fiber. Two spectrographs, one directed axially along the fiber and the other at 60 degrees to the axis were used to compare line intensities in the two directions. From the spectrograph measurements, gain-length products up to 5 were measured with fibers of 2- to 6-μm diameter with a strong dependence on laser energy in the 5- to 8-J range. Substantial agreement with computer models was obtained, as was a high degree of consistency between observations carried out at different times. These landmark results were the first to demonstrate recombination lasing in the soft x-ray regime. Recently, a similar technique using aluminum rather than carbon demonstrated gain at shorter wavelengths. This experiment is discussed below.

Following this initial success, the experiment was repeated at the Central Laser Facility of the Rutherford Appleton Laboratory (RAL) in Didcot, Oxfordshire. The aims were to confirm initial results, to improve the irradiation geometry, and to extend measurements to higher power. Carbon fibers about 5 μm in diameter were irradiated with four cylindrically focused and symmetrically arranged laser beams of 0.53-μm wavelength, 200-ps duration, and up to 30-J total energy. Results were disappointing. Most measurements showed no gain. A few showed gain values of about 0.5 cm^{-1} (as compared with 20 cm^{-1} in the original experiments), and even these were not reproducible. The objective of Pert's talk at ECLIM was to explain discrepancies between the two experiments.

Numerical analyses of the experiments were carried out using the two-dimensional hydro code Pollux and the code Gain for atomic physics. The hydro code provided time histories for electron density, electron temperature, and ion temperature. The atomic physics code used these plasma parameters to determine the distribution of ionization levels and excited states as a function of time. Gain is achieved in these calculations when the population of the n = 3 state exceeds that of n = 2. An example of the calculated time dependence of excited state populations is shown in Figure 1 for optimal laser

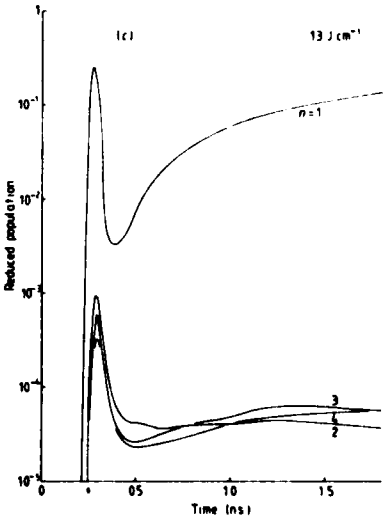


Figure 1. Population levels in H-like carbon versus time.

heating (13 J/cm) of a 3-μm-diameter fiber. At lower energy, excited state populations are higher than shown because of accelerated recombination at lower temperature. However, inversion occurs late in time, when the expanding cylinder of plasma is too low in density for high gain. At higher energies than optimum, inversion occurs early--but gain is low because of reduced populations.

When the codes are used to model the 5-μm-diameter fibers of the RAL experiment, a new aspect of the hydrodynamics becomes important. Early in the heating pulse, a low-density hot plasma blanket expands to fill the laser focal spot. This blanket encloses a dense residual core which remains cool and slow moving. When the incident laser radiation is of low intensity (as in the original Hull experiments), most of the fiber mass remains trapped in the core, and the blanket's density and temperature are appropriate for gain. At somewhat higher laser energies, either the blanket is too hot or the entire plasma is too dense for high excited-state populations. At absorbed laser energies in excess of 40 J/cm, the entire plasma can be heated to the correct temperature, and gain can again occur. The RAL experiments--with most shots in the 10- to 30-J/cm range--were conducted in the intermediate regime, where low or no gain is predicted.

Where to go from here? For the next round of RAL experiments, Pert plans to reduce the fiber diameter to about 4 μm, thereby allowing uniform heating to the high intensity operation condition with the available laser energy.

One key point in Pert's analysis is that population inversion can only be established when the plasma density is below a certain value. This feature was also observed in the aluminum recombination laser experiments performed by T. Jamelot and coworkers at the Université Paris-Sud and the École Polytechnique, Palaiseau, France (*ESN* 36-10:272 [1982]). Jamelot attended ECLIM but discussed his preliminary results informally rather then in a conference contribution. In his experiment, the expanding plasma was produced by line focusing 2-ns and 20-ns CO_2 laser pulses of 100-J energy onto an aluminum slab. The diagnosis was somewhat more sophisticated than Pert's in that Jamelot could look for gain at different points in the expanding plasma density profile. Gain in the 3d-5f transition of Li-like aluminum was observed at all points in the profile with 20-ns pulses, but only in the lower density regions with 2-ns pulses. The experimental results were corroborated by analysis. Rate equations for Al^{+10} and Al^{+11} were solved assuming a 1-keV plasma temperature. The calculations predicted population inversion for the 105.7-angstrom transition only at plasma densities below 10^{19} cm^{-3}, a density consistent with the gain profiles of the 2- and 20-ns experiments.

W. Brunner, Th. Schlegel, and G. Wallis (Central Institute of Optics and Spectroscopy, Berlin, German Democratic Republic) presented calculations for the carbon recombination system and similar systems in other elements; the calculations agreed qualitatively with the density dependence observed in the UK and French experiments. The researchers solved a set of rate equations for level population densities in hydrogenic carbon ions. The model contained radiation reabsorption and stimulated emission in the n = 2 and n = 1 Lyman-alpha lines and transitions to the He-like ionization state. All levels with quantum numbers greater than four were connected to an effective pump level.

The population densities for the n = 3 to n = 2 lasing transition were calculated for electron temperature T between 0.5 eV and 50 eV and electron densities less than 10^{18} cm^{-3} in collisional-radiative equilibrium. The critical density for inversion N was plotted as a function of electron temperature for different lengths L of the lasing medium. Results were generalized to include lasing in other elements and ionization states Z by using $(N/Z)^6$ as the dependent variable. This reduced density increases roughly like $(LT)^{\frac{1}{2}}$ and has a value in the range of 10^{13} to 10^{14} cm^{-3} for plasma lengths and temperatures of the two experiments. Using Z = 5 for carbon and Z = 10 for aluminum gives rough agreement with experiment. However, estimates of gain at the optimal density are substantially lower than the 20 cm^{-1} observed in the Hull experiments--the highest calculated value is only 0.6 cm^{-1}. Thus, although the model presented by Brunner and coworkers seems to indicate the correct regimes for laser operation, more sophisticated analysis is clearly required for accurate gain predictions. By the way, Pert's codes are also unable to predict the measured gain accurately due to the extremely sensitive dependence on small uncertainties in rate coefficients.

Resonantly Pumped lasers

Collaborating researchers from Trinity College, Dublin, Queen's University of Belfast, Hull University, and RAL described a preliminary investigation of x-ray population inversion using resonant photo-excitation. In this approach, the 11-angstrom resonance line of Na X is used to pump the equal energy n = 4 energy level of Ne IX. Inversion of this level can produce lasing transitions at 230 angstroms by decay to n = 3 and at 58 angstroms by decay to n = 2. Cascade to the n = 3 state with subsequent decay to n = 2 produces an additional 82-angstrom transition (Figure 2).

In one laser-driven version (Cochran et al.), the helium-like sodium pump is heated, and the neon ablation plasma is prepared by the same laser pulse. Radiation-hydrodynamic calculations indicate that careful tailoring of the driving pulse will be needed to produce strong coupling of the pump line to the neon and the proper neon density and temperature at the same time. The work of the Irish/English collaboration attempted to avoid this difficulty by employing individually directed and timed laser pulses for the neon and sodium. The laser target was constructed by ion-implanting neon into one side of a thin aluminum foil and depositing a thin layer of sodium fluoride on the other side. The neon side was first irradiated with a 100-ps laser pulse in a 300-μm-diameter spot with 2 to 4×10^{14} W/cm^2 of 0.53-μm light. About 300 ps later, the neon-containing plasma had reached the conditions appropriate for lasing, and the sodium fluoride side of the target was irradiated. A hydro code was used to determine the time of proper neon plasma conditions. Space-resolved x-ray spectroscopy was used to investigate the ionization state of the neon plasma. The effect of the pumping radiation on the neon plasma was investigated by recording the neon spectrum with and without the pumping radiation. Time-resolved x-ray spectroscopy was also used to measure the time history of the pumping pulse. No evidence of inversion was observed in these first attempts, but work continues.

The sodium-neon system recently has received considerable attention with the development of pulsed-power-driven x-ray line sources. Capacitor banks or pulsed-power generators are used to electromagnetically implode high-energy-density plasmas created from puffs of gas or an array of vaporized filaments (*ESN* 37-3: 115 [1983]). At peak compression, the high atomic number plasmas radiate characteristic x-ray lines in the kiloelectronvolt regime. The intense lines can pump a lasing transition in the same element (Dukart et al., 1983) or in another. A group of plasma and atomic physicists at the Blackett Laboratory of Imperial College have recently received UK Science and Engineering Research Council funding to investigate the two-element concept using a layered cylindrical implosion of sodium and neon (*ESN* 37-9:273 [1983]).

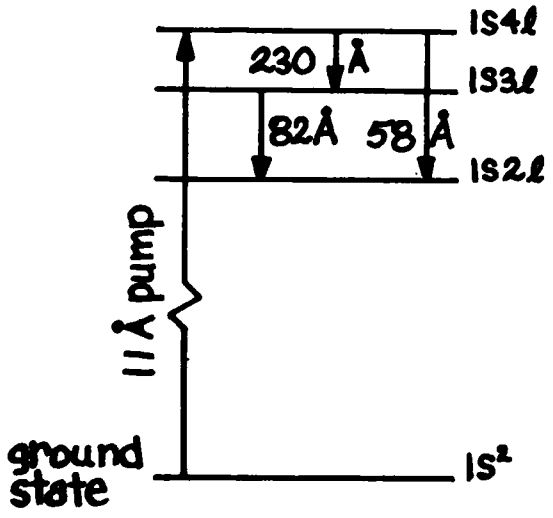


Figure 2. Level diagram for Ne IX.

References

Cochran, F.L., J. Davis, and J.P. Apruzese, submitted to the *Journal of Applied Physics*.

Dukart, R.J., et al., *Proceedings of the 5th International Conference on High Power Particle Beams* (San Francisco, 12-14 September 1983).

Jacoby, D., G.J. Pert, L.D. Shorrock, and G.J. Tallents, *Journal of Physics*, B15 (1982), 3557-3580.

11/30/83

SCIENCE POLICY

UK RESEARCH COUNCILS AND BASIC SCIENCE

by James W. Daniel, Scientific Director for Europe and the Middle East for the

Office of Naval Research's London Branch Office. Dr. Daniel is on leave until August 1985 from The University of Texas, where he is Professor of Mathematics, of Computer Sciences, and of Education.

Most direct financial support for research in basic science in the UK--especially in the universities--comes from the five Research Councils. About five-sixths of the Research Councils' funds are allocated by the government's Department of Education and Science in its so-called Science Budget. This article, based on my recent meeting with the Department's permanent secretary, briefly sketches the roles of the Research Councils and describes the scientific priorities that have been recommended for them by the Advisory Board for the Research Councils.

Background

Although the UK's Ministry of Defense contributes almost four times as much to R&D efforts as do the Research Councils, only a small part of this (now about $13,500,000 annually--see *ESN* 38-1:53-55 [1984]) supports unclassified basic research; the approximately $900,000,000 annually that the Research Councils now spend is thus by far the largest component of direct support for basic scientific research, with much of this being spent in universities or other facilities that university researchers use.

I should explain my use of the term "direct support" above. When a Research Council provides monies to a university for a fellowship, for equipment, for a researcher's salary, and so on, those funds go to support the direct costs; indirect overhead costs--such as office space, laboratory space and equipment, and clerical support--are met by the university from its own funds. This arrangement is called the "dual support system" for research. University contributions to support research through these indirect costs amount to around $550,000,000 annually.

The Advisory Board for the Research Councils (ABRC) is composed of distinguished scientists: 12 of the present 20 board members are Fellows of the Royal Society, and seven have been knighted; the membership includes the chairmen of the Research Councils, chief scientists of some government departments, high level university administrators, and other scientists from public and private organizations. The Board advises Sir Keith Joseph, Secretary of State for Education and Science, on the allocation of the Science Budget among the Councils as well as on other Council matters; since the Secretary usually follows those recommendations, the Board has a great deal of influence on the overall directions taken by individual Councils. The Board members' advice also reveals the scientific directions that a distinguished group of the UK scientific leaders feels should be emphasized; this can help indicate where UK science is heading.

The Board's recommendations are contained in an annual "Forward Look." (Only the Forward Look leading to the present 1983 budget has ever been available to the public; most of my information on Board recommendations for the Councils comes from that 1982 Forward Look.) Budget limitations have made the job of the Board and the Secretary extremely difficult; in real terms, the total funds available for the five councils have recently fallen 2 to 3 percent per year, and the downward trend is expected to continue for several years at least. Difficult choices must therefore be made if research emphasis are to shift.

AFRC

Because of increased emphasis on food research, the Agricultural Research Council is being renamed the Agricultural and Food Research Council (AFRC); I will refer to it here as the AFRC even prior to the name change.

The AFRC funds research in the sciences relevant to agriculture, food, and horticulture; most supported research in the former two areas is conducted by the Agricultural Research Service: eight directly controlled institutes, 14 grant-aided institutes, and 13 groups in universities. The AFRC also awards grants for work on animals, food, plants, soils, and engineering. Historically, it has received only about half of its funding from the Science Budget; the other half has come from performing contract research for government agencies such as the Ministry of Agriculture, Fisheries, and Food.

The ABRC has singled out the AFRC for recommended reductions in its share of the Science Budget in order to increase other areas. The Forward Look recommendations called for $69,600,000 (9.2 percent of the Science Budget) for 1983-84; $70,350,000 (8.8 percent) for 1984-85; and $70,200,000 (8.5 percent) for 1985-86. Although the Secretary treated the AFRC somewhat more generously than was recommended for 1983-84, it now appears that the 1984-85 allocation will be only $68,850,000. Since commissioned research is also falling, the

AFRC is in for hard times and expects to eliminate many positions at its institutes. However, the increased emphasis on food research has produced large budget increases for the Food Research Institute at Norwich and the Meat Research Institute near Bristol, meaning that the institutes on fields such as animal diseases and plant physiology face drastic cuts. In addition, the AFRC is increasing that fraction of its allocation from the Science Budget that goes to university research from its present 10 percent to about 15 percent, an increase of about $3,500,000 per year.

The ABRC's Forward Look supports the AFRC's plan to emphasize research in the genetic manipulation of animals, the application of biotechnology to vaccine production, and the micro-propagation of plants.

ESRC

The Social Science Research Council is being renamed the Economic and Social Research Council (ESRC). The ESRC, UK's largest source of funds for social science research, supports work in psychology, sociology, economics, political science, and their application areas in business management, education, and urban planning. Most of its research support is through university grants, although it does operate four institutes of its own (the best known concerns the history of population and social culture).

Essentially all of the ESRC's income is from the Science Budget, and the ABRC had identified it for a constant share: $34,950,000 (4.6 percent of the Science Budget) for 1983-84; $36,750,000 (4.6 percent) for 1984-85; and $38,250,000 (4.6 percent) for 1985-86. This share represented a slight increase over its 4.5 percent portion in 1982-83, but the Secretary did not approve the recommended increase.

The Forward Look supports the ESRC's plan to emphasize international economics, law and order, health economics, addiction, unemployment, and energy.

MRC

The Medical Research Council (MRC) supports research on physical and mental health and on biomedicine. It has 58 research establishments, many associated with universities or hospitals, but spends about 40 percent of its Science Budget funds on research and training in the universities.

According to the ABRC recommendations, the MRC share of the Science Budget should stay essentially constant: $170,700,000 (22.5 percent of the Science Budget) for 1983-84; $178,650,000 (22.4 percent) for 1984-85; and $185,850,000 (22.4 percent) for 1985-86. Roughly another $8,000,000 comes to the MRC from contract research and other income each year.

The MRC was supported by the ABRC in its plans to emphasize research on cancer treatment, hypertension, nuclear magnetic resonance imaging, perinatal medicine, diabetes, and multiple sclerosis; new initiatives in psychiatry, mental retardation, occupational health, teratology (study of abnormalities), and toxicology were applauded.

NERC

The Natural Environment Research Council (NERC) supports research in geology, geophysics, geochemistry, physical oceanography, ecology, hydrology, and atmospheric science. Nine institutes are entirely operated by the NERC, and another five are supported with grants. Its fleet of ocean-research vessels--including two for polar work--indirectly supports university researchers by providing facilities for gathering data; research grants to universities are also awarded.

The NERC usually obtains about one-third of its budget from contract research and other income, although the availability of such sources is decreasing. The ABRC has recommended essentially a constant share of the Science Budget: $87,600,000 (11.5 percent of the Science Budget) for 1983-84; $91,800,000 (11.5 percent) for 1984-85; and $94,800,000 (11.4 percent) for 1985-86. In an attempt to maintain the real value of the amounts allocated to university grants while facing 7-percent inflation but only 3- to 5-percent budget increases, the NERC has reduced its support of its institutes on conservation, pest control, and geological map making. It also established a Research Marketing Group to attract nongovernmental contract research as a new source of income.

The ABRC urged the NERC to increase its emphasis on research in remote sensing. It also supported NERC plans to push research in marine sedimentation, ocean chemistry, forestry (with the AFRC), biotechnology of aquatic organisms, and atmospheric science.

SERC

The Science and Engineering Research Council (SERC) is the largest of the five, receiving about half of the Science Budget. In funding research in astronomy, biology, chemistry, engineering, mathematics, and physics, it devotes most of its monies to support the universities in order to sustain

high standards of university research and postgraduate education. Although its four laboratories--Rutherford Appleton Laboratory, Daresbury Laboratory, the Royal Greenwich Observatory, and the Royal Observatory in Edinburgh--are world famous, they are operated not as independent centers but as facilities in which faculty members can perform research in capital-intensive subjects. (A separate report on the SERC will appear in a later issue of *ESN*.)

About 96 percent of the SERC's funds comes from the Science Budget, of which the ABRC has recommended an increasing share: $375,000,000 (49.3 percent of the Science Budget) for 1983-84; $397,200,000 (49.8 percent) for 1984-85; and $416,250,000 (50.2 percent) for 1985-86. Because of inflation, however, this increased share and increased budget represents a real loss of 1 to 3 percent per year. And since part of the cash increases are for increased emphasis on information technology ($7,500,000 increase for 1984-85, for example) and space ($3,000,000 increase for 1984-85, for example), the SERC is in for some belt tightening if it is to maintain the level of university grants as planned.

Besides urging the increased support mentioned above for research in information technology and space, the ABRC supported SERC plans to emphasize biotechnology, remote sensing (with the NERC), and civil engineering. A commitment to hold steady its support for "big science" means that support for such areas as marine technology and polymer engineering will fall.

Conclusions

The ABRC's Forward Look depicts some moderately troubled times for scientific research in the UK; the recommended Science-Budget allocations to the five Research Councils--$737,850,000 for 1983-84; $774,750,000 for 1984-85; $805,350,000 for 1985-86--constitute a loss in real income of 2 to 3 percent per year. The ABRC and the Councils all seek to hold steady their support of university research because of the financial losses universities have suffered in their direct allocations from the government. Combine this intention with the ABRC's desire to significantly increase emphasis on areas such as biotechnology, food, remote sensing, information technology, marine science, and space, and you'll see that other areas of science are going to have to punch several new holes in their belts.

11/21/83

SPACE SCIENCE

AIRBORNE INFRARED TELESCOPE

by R.L. Carovillano. Dr. Carovillano is the Liaison Scientist for Space Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1984 from Boston College, where he is Professor of Physics.

The Max-Planck-Institute for Extraterrestrial Physics has initiated a study to do infrared astronomy with an airborne telescope. As envisaged, the program would be managed and financed by a consortium of European research organizations. Suggested investigations would be complementary to current ground-based and satellite infrared (IR) programs, and would be preparatory to proposed or planned infrared satellite missions for the 1990s.

The absorption of electromagnetic radiation by the atmosphere limits the capability to do astronomy at certain wavelengths from the surface of the earth. The atmosphere is transparent primarily at optical wavelengths and to a lesser extent at radio wavelengths. Other wavelengths are absorbed by the atmosphere, the degree of absorption decreasing with altitude. Another complication in conducting earth-based observations of outer space is the electromagnetic emissions of atmospheric molecules that create an unwanted background radiation.

Vibrational and rotational emissions of molecules occur mainly at IR and submillimeter wavelengths. The molecules H_2O and CO_2 are abundant in the earth's atmosphere and play a particularly obscuring role in the observation of radiation from extraterrestrial molecules. To date, infrared observations of outer space have been conducted primarily with balloons and satellites--particularly IRAS, the Infrared Astronomy Satellite that was launched in January 1983 and recently stopped operating. A substantial reduction of atmospheric molecular absorption of IR radiation is obtained at the highest cruising altitudes of commercial aircraft, and this provides a new approach to the study of extraterrestrial molecules. For example, whereas the average atmospheric transmission in the IR wavelength range of 30 to 1000 μm is essentially zero at an altitude of 4.2 km, it exceeds 75 percent at 14 km (or 46,000 feet).

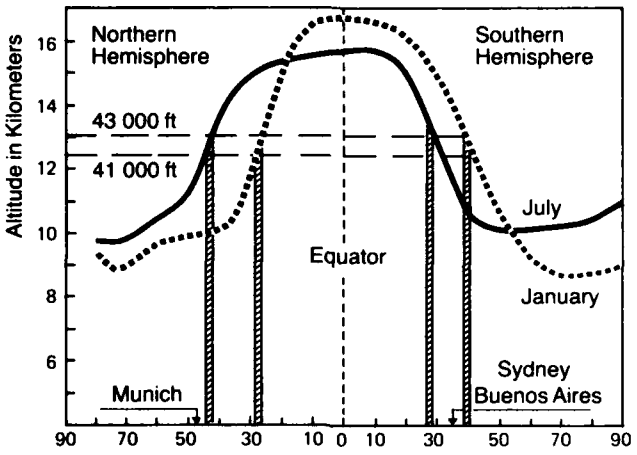


Figure 1. Variation in the height of the tropopause.

The current plans are to conduct IR observations in a jet plane cruising above the tropopause. The advantages of conducting extraterrestrial observations at such altitudes derive from the diminished overhead atmosphere. Atmospheric background radiation from emission and absorption is greatly reduced; background radiation effects are more stable, less variable, and more easily accounted for because of the simplified atmospheric structure; and air turbulence is less. The height of the tropopause varies with latitude and season, as shown in Figure 1. At contemplated cruise altitudes, northern hemisphere observations can be made to latitudes above about 28 degrees in the winter and 45 degrees in the summer. Southern hemisphere observations are equally possible, and at least one such flight per year is expected.

There are four principal objectives of the proposed European airborne IR and submillimeter observatory:

- To provide the European community with a versatile and powerful IR telescope at moderate cost
- To provide the capability to react quickly to scientific questions arising from new discoveries or measurements
- To perform measurements complementary to ground-based, balloon, or satellite observations
- To train students and researchers in IR techniques preparatory to launch of the proposed satellite telescopes in the next 5 to 10 years.

The planned program would accommodate both planetary and astronomical investigations. Planets, satellites, and comets have relatively cool atmospheres containing complex molecules and dust that radiate mainly at IR and submillimeter wavelengths. Spectral lines and features are related to atmospheric composition and physical structure. High resolution spectroscopy can be used to determine isotopic ratios which relate to the age of the object and the origin of the solar system. By assigning a substantial priority to planetary observations, an area of research inadequately emphasized by astronomers, the airborne program would be providing a valuable scientific service.

Interstellar gas contains molecular clouds and dust particles that absorb visible light but are highly transparent in the IR and submillimeter regime. Comparison of IR and visible observations would give information on the distribution of interstellar matter and the early stages of star formation. The environments of systems such as stars, clusters of stars, and galaxies all emit IR radiation as they evolve. IR astronomy is a young field, and almost any chosen observations can be expected to provide exciting new discoveries. For example, the IRAS satellite discovered about 1000 IR sources per day in its all-sky survey. Selected IRAS sources would be studied in the airborne program with detailed photometry and high resolution spectroscopy.

The planned aircraft will be the Canadair CL-601 Challenger, which made its first flight in April 1982 and had deliveries scheduled for early 1983. The Challenger has two General Electric jet engines and winglets, a range of 4030 miles, a maximum certified flying altitude of 45,000 feet, and a landing distance of 4000 feet. The payload when

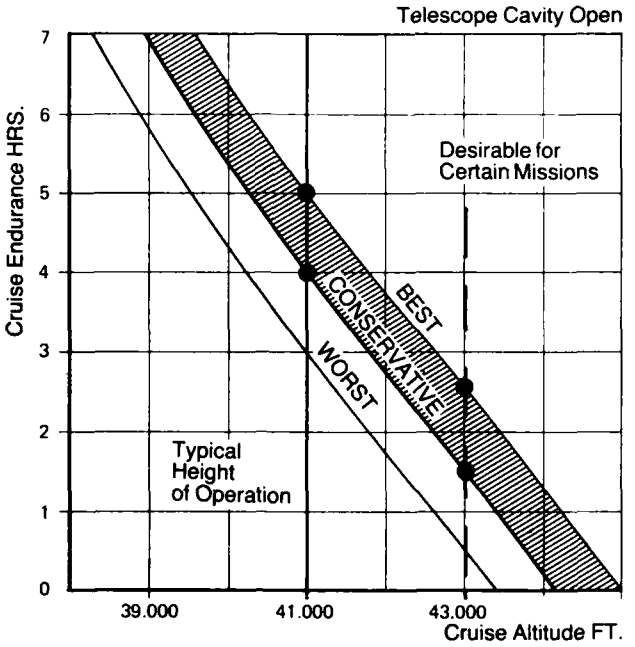


Figure 2. Aircraft's cruise endurance.

the aircraft is fully fueled is 1000 pounds. The cruise endurance of the aircraft depends on altitude, as shown in Figure 2. Observational runs of 1.5 to 5.0 hours would be possible, depending on the season.

The cabin of the CL-601 will accommodate two scientists or operating specialists, the telescope, and auxiliary equipment. During observations, the telescope must operate in an open cavity, since any substantial window would excessively diminish the IR signal.

The primary instrument would be a 1-m Ritchey Chrétien telescope located in a cavity above the wings. The telescope would have an aperture diameter of 1000 mm, f/18 focal ratio, a 3- to 6-arcsec pointing accuracy, and a wavelength range of 5 to 1000 μm. Pointing capability would range from 17 to 60 degrees in elevation angle and ±4 degrees in azimuth orthogonal to the line of flight. Depending on wavelength, the minimum detectable flux density would range from 3×10^{-18} to 3×10^{-17} W/cm^2. The telescope operator console would include a control computer, manual controls, altitude and memory controls, and other devices. Experiment control would be facilitated by data memory and display capabilities.

The telescope would be precooled before flight. During ascent and descent, the telescope cavity would be sealed in a controlled air and pressure environment. Effects of aircraft vibration would be reduced by use of pneumatic shock absorbors and a special mounting.

In addition to conducting IR and submillimeter astronomical observations, the CL-601 aircraft would be used approximately half-time in the remote sensing research program of the German space agency (DFVLR). Both the astronomy and remote sensing programs are envisaged to be joint activities of several European research organizations. Other foreign participation may also be possible.

The proposed management structure of the airborne IR program is shown in Figure 3. Several European research organizations are expected to participate. The Council would supervise the financial and technical status and determine the overall scientific scope of the program. The coordination office would plan flights, supervise the installation and removal of the IR telescope and other instruments from the aircraft, and interface with the DFVLR and airport authorities. The Scientific Program Committee would have the difficult task of selecting proposals on the basis of scientific merit and apportioning observation time. Research proposals would come from groups from

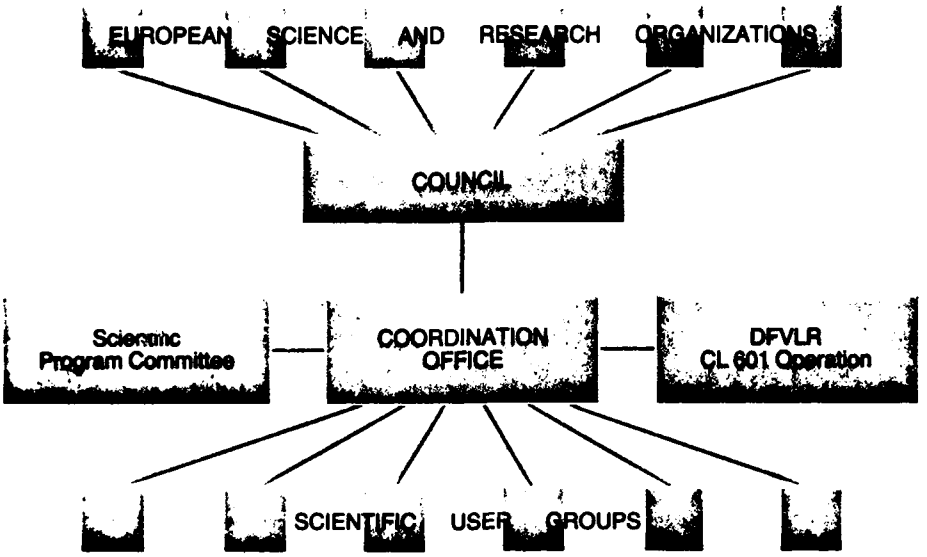


Figure 3. Structure of the program.

participating countries, and available flight time would be proportioned to the degree of national financial support of the program.

Estimated costs of the airborne IR program are quite modest. The DFVLR would purchase the CL-601 aircraft and provide necessary ground facilities at the Dornier airfield near Munich. Development costs would be about $3.3 million for aircraft modification and $4.6 million for the telescope system. With 300 flight hours per year for IR astronomy, annual operating costs are estimated at less than $500,000. The program can become operational by late 1986.

Further information on the IR program described above can be obtained from:

Dr. G. Haerendel
Max-Planck-Institut für Physik and Astrophysik
Institut für Extraterrestrische Physik
8046 Garching b. München
FEDERAL REPUBLIC OF GERMANY

11/30/83

STATISTICS

STATISTICS RESEARCH AT SMALL GERMAN UNIVERSITIES

by D.R. Barr. Dr. Barr, formerly at ONR, London, is Professor of Statistics and Operations Research at the Naval Postgraduate School, Monterey, CA.

The Federal Republic of Germany (FRG, or West Germany) has a large and diffuse system for conducting research. The FRG spends more on R&D than any other country in Western Europe; per capita spending on R&D is about twice that in Britain, for example.

Universities consume roughly one-sixth of the total research expenditures of the federal and state governments. The FRG has a surprisingly large number of moderate- to small-sized universities--over 60 universities in the FRG have the right to award doctoral degrees, and approximately 100 additional institutions have undergraduate and master's degree programs.

Though the universities tend to be small by US standards, many have long and distinguished histories and are producing quality research. The statistics group at a typical small German university consists of one or two "institutes" (essentially mini-departments within the university's mathematics department). Each institute is chaired by a professor, who has one or two assistants with PhD degrees; all actively do research. At any given time, these groups might be responsible for 10 to 15 master's students and four or five PhD students. The statistics groups generally concentrate on mathematical statistics; statistical applications courses are usually taught in applications departments such as sociology, psychology, and economics. This

article reports a sample of research activities at two such universities, both located in the northern part of the FRG.

The statistics group at the University of Marburg is chaired by Prof. Volker Mammitzsch. Mammitzsch and an assistant, Dr. Raimund Rhiel, have been working on sequential decision rules in continuous time. For a large class of such sequential decision problems the problem of finding an optimal rule can be reduced to that of finding an optimal stopping rule for an appropriate stochastic process $\{X_t\}$, which they call the "stochastic decision process." Mammitzsch and Rhiel have derived conditions with respect to the basic data ensuring the process has continuity properties sufficient to yield an optimal stopping time. A closed form of the process $\{X_t\}$ has been derived for the case of conjugate priors and fairly general loss functions, and in special cases explicit expressions for the optimal stopping rules have been found. To a large extent these results exploit modern martingale theory.

Mammitzsch has recently obtained some interesting results on the asymptotic distribution of ordered distance random variables under quite general conditions. Suppose $X_0, X_1, \ldots, X_m$ are independent n-dimensional random vectors, where X_0 has density g and $X_1, \ldots, X_m$ have common density f. Let $Y_k = ||X_k - X_0||$, where $||\cdot||$ is any norm, and let $Z_k^{(m)}$ be the kth order statistic of the Y's, called the kth ordered distance random variable; k = 1, 2, ..., m. Mammitzsch has shown that

$$\lim_{m\to\infty} P\left(\sqrt[n]{m}\, Z_k^{(m)} \le r\right) = 1 - \sum_{j=0}^{k-1} \frac{V(r)^j}{j!} \int_{\mathbb{R}^n} e^{-v(r)f(x)} f(x)^j g(x)\,dx,$$

where V(r) is the volume (with respect to Lebesgue measure) of the n-dimensional ball $\{x \in \mathbb{R}^n : ||x - x_0|| < r\}$. This is a significant extension of earlier works which assume f = g and $||\cdot||$ is the Euclidean norm.

Josef Steinebach is another professor in the statistics department at Marburg. He has been working on problems related to estimation theory, and in particular to notions of asymptotic efficiency and the asymptotic description of fluctuations of random processes. His results are interesting from a probabilistic as well as a statistical point of view, because asymptotic properties of increments of certain stochastic processes can be characterized. Such properties determine the underlying distribution in several special cases which are of statistical interest. A review of the problem and Steinebach's approach is given in his paper, "The Stochastic Geyser Problem for First-Passage Times," *Journal of Applied Probability*, 18 (1981).

The mathematical statisticians at the Technical University of Braunschweig are in the Institute of Applied Mathematics, chaired by Prof. Ernst Henze. Henze and his two associates, L. Schüler and H. Wolff, are working on several research projects. One area of particular interest is density estimation: on the basis of a random sample from a continuous multivariate population, it is desired to obtain a parameter-free estimate of the corresponding density function, f.

Multivariate density estimates are useful in a variety of statistical applications. For example, many classification methods essentially classify an observation as belonging to the class associated with the "nearest bump" on the density; this is closely related to decomposition of mixtures of distributions. Yet another application is in cluster analysis in the case of an unknown number of overlapping clusters. The approach of the Braunschweig group is based on series expansions of the unknown density in terms of orthogonal function systems, say

$$f(x) \approx \sum_{i=1}^{m} a_i \delta_i(x),$$

where $\{\delta_i\}$ is the system of Hermite functions. (It is claimed that estimators based on this system of functions are more amenable to computation than are estimators based on trigonometric systems, for example.) There are several problems under consideration: what is the best choice of truncation point m of the series? Which estimators $\hat{a}_i$ of coefficients in the truncated series give the best density estimate? Henze and his coworkers have developed computer programs for carrying out estimation of f with estimators $\hat{a}_i$ that

they have derived. These methods require heavy computation for population dimensions greater than four or five, and Henze suggests dimension-reduction approaches principal components, linear discriminant analysis, or more sophisticated nonlinear methods) should be applied when possible, before entering a density-estimation routine. The group is now working on estimation when the distribution changes with time. One approach they are trying is a "learning" model based on stochastic approximation.

The group is investigating Markov processes of higher order--i.e., processes in which the transition probability at a given time (present) depends on more than one observation at an earlier time (past). One significant result they have obtained is that under weak regularity assumptions on the realizations of the process (for example, existence of only one-sided limits), Markov processes of higher order do not exist--they degenerate into Markov processes of first order. Attempts to give alternate definitions for such a class of processes have so far not been successful.

Henze is also interested in information encryption systems. He recently published a characterization of one-way functions of any general public key encryption system, "The Solution of the General Equation for Public Key Distribution Systems," *IEEE Transactions on Information Theory*, IT-28 (1982). He showed that the public key of any two members of a general public key distribution system must satisfy the functional equation $f(f(x,a),b) = f(f(x,b),a)$, and gave the form the solution, f, must have. Henze told me he believes the best encryption system for single-user data security is one based on a random number generator. In this system, each character to be encoded is mapped by a randomly selected permutation of the alphabet to its encrypted image. The sequence of permutations is selected in accordance with outcomes from the random number generator. The key for the system is then the seed of the random number generator. The main problem with this approach, according to Henze, is in obtaining a suitable random number generator.

11/17/83

NEWS & NOTES

FRENCH SUMMER SCHOOL ON INTERNAL GEOPHYSICS AND SPACE

The Centre National d'Études Spatiales (CNES) has announced that its next Summer School of Space Physics will take place from 2 through 28 July 1984 in Toulouse, France. The CNES summer school has been conducted biannually since 1966 with a curriculum on some theoretical aspect of space physics. The theme of the 1984 school is Internal Geophysics and Space. Attendance will be restricted to about 40 French and other researchers with at least the equivalent of an MS degree. Lectures will be in French or English without simultaneous translation provided.

The topic of the 1984 school was chosen because of the important advances concerning the geophysics of the earth's interior attributable to space observations made in the past decade or so. Space geodesy has improved our understanding and knowledge on a global scale of phenomena such as the gravity field of the earth, the rotation of the earth, tides, the geomagnetic field, the hydrosphere, and crustal structures. Results from past satellites (such as LASER, DOPPLER, MAGSAT, GEOS, and SEASAT) will be used and experimental capabilities on planned satellites discussed. The latter include satellites that will provide remote sensing at optical wavelengths (SPOT), synthetic aperture radar, accurate positioning systems, and very long baseline interferometry for crustal dynamics studies (e.g., TOPEX, POSEIDON, and ERS).

The summer school will consist of lectures and conferences. The lectures will deal with the geomagnetic field, the gravimetric field, convection processes in the mantle, the continental and oceanic lithosphere, tectonics and crustal structure, earth dynamics and seismology, internal energy sources, and chemical geodynamics. Lecturers tentatively include J.-L. Le Mouel, C. Allegre, P. Taponnier, and C. Jaupart (Institut de Physique du Globe, Paris); P.H. Roberts (University of Newcastle upon Tyne, UK); D. McKenzie (University of Cambridge, UK); B. Lago (CNES, Toulouse); D. Turcotte (Cornell University, NY); A.B. Watts (Lamont Doherty Geological Observatory, NY); E. Okal (Yale University, CT), and T. Jordan (Scripps, CA)

Conferences will cover a number of topics, including paleomagnetism, MAGSAT, the magnetosphere, the gravimetric field, structure of telluric planets, inhomogeneous convection, tectonics, the oceanic lithosphere, remote sensing image processing, and space geodesy techniques.

Modestly priced accommodations and meals will be available at the conference site. A limited number of scholarships may be available for selected applicants. Inquiries may be sent to:

Centre National D'Études Spatiales
Département des Affaires Universitaires
18, Avenue Edouard-Belin
31055 Toulouse Cedex
FRANCE

R.L. Carovillano
12/1/83

INTERNATIONAL CONFERENCE ON NEW TECHNIQUES IN SONAR TRANSDUCERS SCHEDULED

The Third International Conference on New Techniques in Sonar Transducers is planned for 5 and 6 September 1984 at the University of Birmingham, England. The meeting is being organized by the Underwater Acoustics Group of the Institute of Acoustics. Prospective authors are invited to submit 200-word synopses not later than 5 March 1984. Authors of accepted papers will be notified by 31 March 1984. Complete manuscripts, maximum of 10 pages including diagrams, must be received by 4 June 1984. The conference proceedings will be published in book form, and copies will be available at the beginning of the conference.

Papers covering all aspects of underwater sound transducers are appropriate. Some suggested topics include: finite element analysis, flexural mode devices, novel designs, new materials, plastic film transducers, fiber optic hydrophones, reliability and ageing, and problems in manufacture.

All communications should be sent to the conference secretary, Mr. J.R. Dunn, Department of Electronic and Electrical Engineering, University of Birmingham, P.O. Box 363, Birmingham B15 2TT, England. The telephone number is 021-472-1301, ext. 2504 or 2509.

Chester McKinney
11/17/83

CNES COURSE ON SPACE MATHEMATICS

The Centre National D'Études Spatiales (CNES) has sponsored a course on some aspect of space technology each year since 1965. The subject of the course this year is Space Mathematics for the preparation and development of satellite exploitation. The course will be held in the Toulouse Space Center from 12 to 23 March 1984. The course is directed at engineers, research scientists, and students. The number of participants is limited. Applied mathematics, numerical methods, and the solution of practical problems are emphasized in the curriculum. Lecturers include staff members from CNES and other French institutions, and invited American and European specialists.

The program has two principal sessions on methods and applications. The session on methods includes applied mathematics, numerical analysis, space mechanics, and space data processing. Applications include orbit control of geostationary and other orbiting satellites, the re-entry of satellites, space navigation, space coordinate systems, and other topics. Inquiries on the program may be directed to:

CNES
Département des Affaires Universitaires
18, Avenue Edouard-Belin
31055 Toulouse Cedex, FRANCE

R.L. Carovillano
12/8/83

ONRL COSPONSORED CONFERENCES

ONR London can nominate two registration-free participants in the conferences it supports. Readers who are interested in attending a conference should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

Third UK Solar Maximum Mission Workshop, Oxford, UK, 26-28 March 1984.

Vacuum 84--Technological Aspects of Surface Treatment and Analysis Conference, York, UK, 1-4 April 1984.

Royal Statistical Society 150th Anniversary Conference, London, 4-6 April 1984.

International Symposium on the Properties and Applications of Metal Hydrides IV, Eilat, Israel, 3-9 April 1984.

Second International Meeting on Lithium Batteries, Paris, France, 25-27 April 1984.

International Conference on Laser Processing and Diagnostics--Applications in Electronic Materials, Linz, Austria, 15-19 July 1984.

Tenth General Assembly of the European Geophysical Society, Louvain-la-Neuve, Belgium, 30 July - 4 August 1984.

International Conference on Digital Signal Processing, Florence, Italy, 4-8 September 1984.

NOVEMBER MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during November. The *MAS Bulletin* is an account of naval developments in European research, development, test, and evaluation. Its distribution is limited to offices with the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR London.

MASB Number	Title
123-83	Satellite Meteorology at the UK Meteorological Office
124-83	Mine Warfare Highlights at the 1983 Royal Navy Equipment Exhibition
125-83	A German-British Development of a Carbon-Fiber Composite (CFC) Taileron for the Anglo-German-Italian Tornado Aircraft
126-83	British Crash Records are "Crash Proven"
127-83	Second International Conference on Recent Advances in Structural Dynamics

ONRL REPORT

To request the report, check the box on the self-addressed mailer and return it to ONRL.

C-17-83: *Ninth World Computer Congress: IFIP 83*, by J.F. Blackburn. Highlights of the conference included discussions of the design of Ada, the VLSI/ULSI chip, logic programming, multiprocessor data bases, high-performance computers, fifth-generation computers, dataflow machines, and high-speed processors.

SCIENCE NEWSBRIEF FOR NOVEMBER

The following issue of *Science Newsbrief* was published by the ONR, London, Scientific Liaison Division during November. *Science Newsbrief* provides concise accounts of scientific developments or science policy in Europe and the Middle East. Please request copies, by number, from ONR London.

Science Newsbrief Number	Title
1-3-83	Artificial Intelligence in The Netherlands, by Richard E. Snow.

END

FILMED

3-84

DTIC